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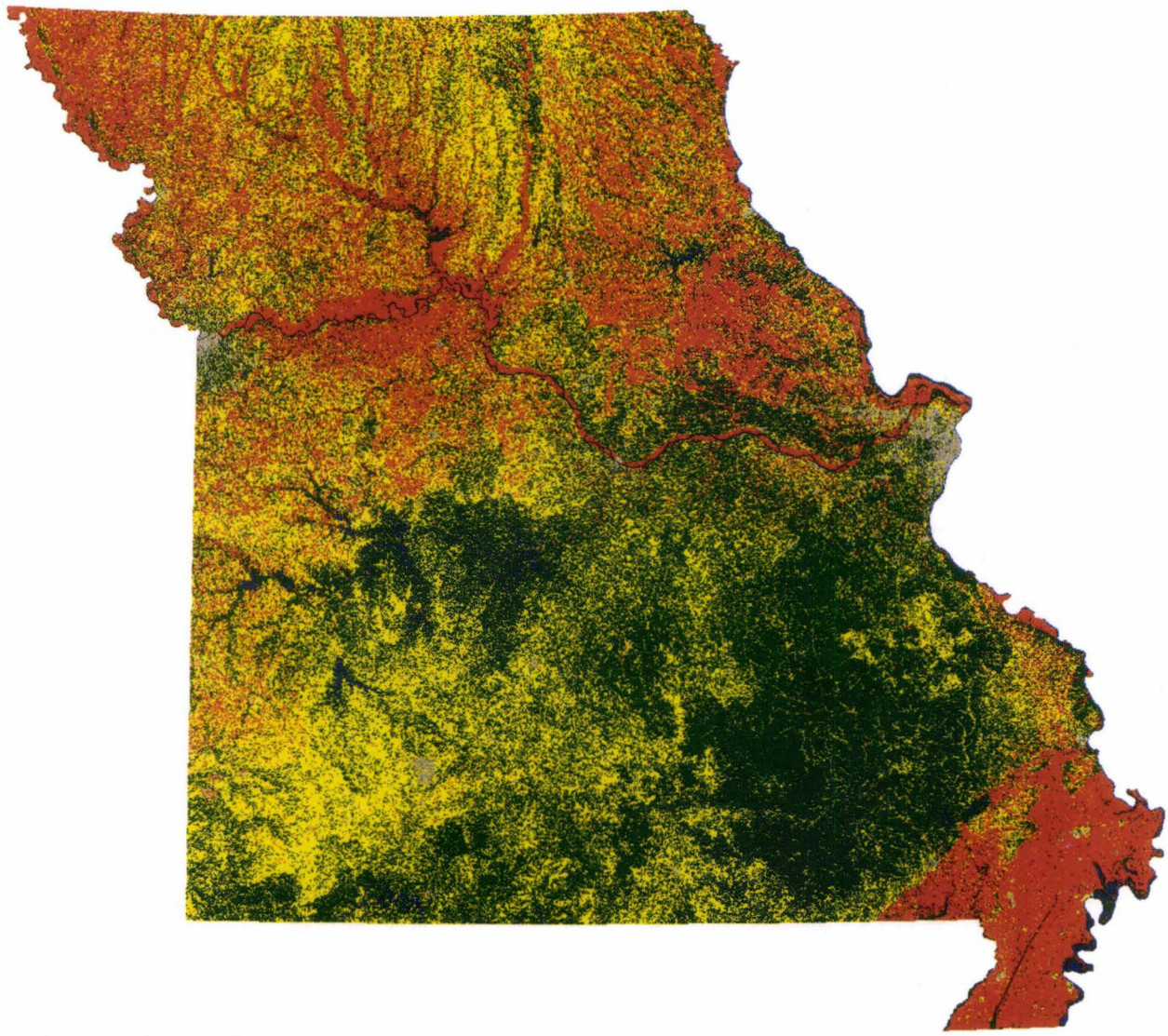
Toward Sustainability For Missouri Forests



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TOWARD SUSTAINABILITY FOR MISSOURI FORESTS

Proceedings of a Conference

Held in
Columbia, Missouri

March 4-5, 1999

Susan L. Flader, Editor

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Introduction

This volume originated in a conference, "Toward a Vision for Missouri's Private Forests," held at the University of Missouri-Columbia in March 1999. One of a series of annual conferences on environmental sustainability and public policy coordinated by the Environmental Affairs Council and the Environmental Studies Program at the University, the conference was planned and cosponsored by a number of state and federal agencies and forestry and environmental organizations.

The conference was stimulated by heightened public interest in forest policy in Missouri occasioned in part by the arrival of two high-capacity chip mills in the southeastern Ozarks in 1997. About the same time as planning began for the conference, Governor Mel Carnahan issued an executive order of September 18, 1998, establishing an advisory committee on chip mills to study the impact of the mills and associated harvest practices on economic and environmental sustainability. Recognizing the desirability of looking more broadly at management and policy issues related to Missouri's 14 million acres of forests statewide, 85 percent of which are privately owned and all of which will be subject to increased demands for timber, habitat, recreation, and other commodities and services, the conference planning committee decided to focus especially on private forests. The federal and state forests of Missouri, which comprise about 13 percent of the state's forest acreage, had been the focus of a previous conference at Southeast Missouri State University in 1992, "Towards a Vision for Missouri's Public Forests" (Journet and Spratt 1992).

As it happened, many of the papers prepared for the March 1999 conference were subsequently presented, at least in part, to the Governor's Advisory Committee on Chip Mills; one paper on forest growth, harvest, and consumption, prepared initially for the Governor's committee, has been recast for this volume. The conference thus had the desired effect of enlarging and deepening the scope of deliberations of the Governor's committee and stimulating public discussion of the issues involved.

This volume includes 10 of the more substantive papers presented at the conference, together with a concluding assessment of the environment of policy development in Missouri as illustrated by the deliberations of the Governor's committee on chip mills, which includes consideration of many issues raised by a range of interest groups during panel discussions at the conference and in hearings before the committee. All papers have been revised, in some cases substantially, to incorporate ideas from dicussions at the conference and suggestions from reviewers, and, where applicable, to relate to the public as well as private forests of Missouri. Our intent is to provide a reasonably comprehensive, authoritative assessment of forest resources and sustainability issues in Missouri that may provide a basis for further consideration of public policy going beyond the recommendations of the Governor's chip mill advisory committee.

The opinions expressed by the authors are their own, not necessarily those of the agencies or institutions for which they work, and the authors do not always agree with each other. Yet, although the conference sought to incorporate a range of ideas and points of view, the authors hold in common a basic concern for sustainability of Missouri forests, however differently they may define it or propose to achieve it.

The issue of sustainability is not new, but it has taken on new meaning and urgency in recent decades. The very notion of *sustained yield* was at the heart of the conservation idea espoused by Chief Forester Gifford Pinchot early in the 20th century, when it had a primarily economic connotation of perpetual production of forest commodities for human use. The Multiple Use-Sustained Yield Act of 1960 codified the gradual extension of sustained yield principles over the intervening years to cover not only timber but also range, outdoor recreation, watershed, and wildlife and fish resources. With the rise of interest in conservation biology and ecosystem management in the 1980s, the concept took on more ecological meaning as conveyed by the notion of forest health, or the sustainability of physical, biotic, and trophic processes that provide for resistance and resilience in accommodating change. The World Commission on Environment and Development in its celebrated 1987 report,

Our Common Future, emphasized the social dimension and the imperative of environmental justice, defining sustainable development as maintenance of the capacity of all nations "to meet the needs of the present without compromising the ability of future generations to meet their own needs."

The concept of sustainable forests was given more precise definition in the 1990s through a broadly participatory international seminar and subsequent initiatives known collectively as the Montreal Process. The process began at the United Nations-sponsored "Earth Summit" in Rio de Janeiro, Brazil, in 1992, at which over 144 nations adopted a nonbinding Statement of Forest Principles. It continued in a UN seminar in Montreal on Sustainable Development of Boreal and Temperate Forests, at which participants began a process of identifying criteria and indicators to measure forest conditions and track changes (Woodley *et al.* 1997). The sustainability framework developed by the Montreal Process Working Group includes 7 criteria and 67 indicators for the conservation and sustainable management of temperate and boreal forests. These have been included in the "Santiago Declaration," a statement of political commitment to use the criteria and indicators to track progress in sustainability that was endorsed in 1995 by the United States, as well as by Argentina, Canada, China, Japan, Mexico, New Zealand, the Russian Federation, and other countries that collectively contain 90 percent of the world's temperate and boreal forests. The criteria—goals that reflect broad public values and recognized scientific principles—are as follows (for the indicators, see appendix A):

1. Conservation of biological diversity
2. Maintenance of productive capacity of forest ecosystems
3. Maintenance of forest ecosystem health and vitality
4. Conservation and maintenance of soil and water resources
5. Maintenance of forest contribution to global carbon cycles
6. Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies
7. Legal, institutional, and economic framework for forest conservation and sustainable management

Criteria 1-5 relate primarily to forest conditions, attributes, or functions, while criteria 6 and 7 characterize interactions between people, their communities, and the environment. These criteria have subsequently been discussed and endorsed by the Northeastern Area State and Private Forestry unit of the Forest Service and the 20 state forestry agencies in the Northeastern Area Association of State Foresters, of which Missouri is a part (USDA-FS 1999). The criteria are discussed with respect to their implications for Missouri in several chapters in part II of this volume, *Elements of Sustainability*.

This volume opens with two papers on the nature and history of Missouri forests. Tim Nigh offers an ecological perspective in chapter 1, explaining the evolution of the remarkable diversity of the state's forest ecosystems, which once covered more than two-thirds of the state, and drawing on accounts of early surveyors and other observers to characterize the nature of the forest at the time of white settlement. He then discusses the composition, structure, and general condition of the 14 million acres of forest ecosystems, approximately 30 percent of the state, that remain, describing an ecological classification system that has been developed in recent years for identifying and mapping ecological units of land at regional, landscape, and local levels.

Susan Flader follows with a *History of Missouri Forests and Forest Conservation* that traces the clearing and exploitation of the forest during the last two centuries, peaking during the period 1890-1920, and the relatively slow pace of early conservation efforts. Progressive leadership from urban conservationists, forestry professionals, and even certain industry executives was repeatedly thwarted by the rural-dominated state legislature, reflecting a political culture, especially in the Ozarks, characterized by a deep distrust of government and a desire to be left alone to subsist on woodland resources without producing heavily for market. The very terms "forest" and "forestry," she suggests, bespoke outside efforts at control that were steadfastly resisted by Ozarkers. She then discusses the establishment of Missouri's pace-setting Conservation Department in the 1930s and the tensions that developed in the

state in recent decades between preservation-minded environmentalists and more commodity-oriented forestry professionals.

Five papers in part II discuss *Elements of Sustainability* with reference to Missouri. In their discussion of *Ecological Sustainability*, Alan Journet and Christine Logan consider aspects of Montreal Process criteria 1, 2, 3, and 5, with a special emphasis on issues in biodiversity conservation that are of major concern in Missouri. They begin with a discussion of the status of and demands on forest ecosystems in a global context, including the problem of global climate change. In focusing more directly on the meaning and implications of ecologically sustainable forestry, they consider first, from a more theoretical perspective, the inevitable human role in the maintenance of health in contemporary ecosystems; they then discuss problems in the conservation of biodiversity and conclude with a discussion of policy implications, grounded in trends or indicators by which progress toward sustainability may be assessed.

In his consideration of *Missouri's Timber Resources* in chapter 4, Stephen Shifley draws on the best available evidence from recent forest inventories and estimates of per capita consumption to demonstrate that Missourians consume far more wood products than they produce—they consume about 400 million cubic feet of products annually while producing only 140 million cubic feet. Assessing forest conditions, growth, and harvest on a regional basis, he concludes that Missouri forests, in spite of their extraordinarily high volume of rough and rotten (cull) trees, are currently being managed sustainably on the basis of timber volume growth and harvest, but he notes that when sustainability is viewed as a relationship between production and consumption, Missouri has a long way to go.

Shifley argues that Missourians, through more intensive management of their forests, could produce a volume of timber that comes much closer to that which Missouri citizens consume, while Journet and Logan, who focus more on ecological values and services of the forest, argue for the need to reduce consumption. The two approaches need not be at odds, but could simultaneously lead to more sustainable forests.

Shelby Jones considers yet another dimension of sustainability in his discussion of *Non-Timber Forest Products*. He argues that sensible harvesting of a virtually endless variety of non-timber products of forest ecosystems can provide sufficient annual revenue to allow forest owners to commit the investment capital necessary for more sustainable management of their land for the 80 to 100 years required for conventional forest products. Among the alternative products he discusses are cones and seeds, pollen, decorative wood and horticultural products, medicinals and pharmaceuticals, bark, wild edibles such as berries, fruits, nuts, and mushrooms, and leasing of land for recreational enterprises. The papers of Shifley and Jones are relevant to Montreal Process criteria 2 and 6 dealing with productive capacity and socioeconomic benefits.

Robert Jacobson's discussion of *Watershed Sustainability: Downstream Effects of Timber Harvest in the Ozarks of Missouri* is particularly relevant to Montreal Process criterion 4 dealing with conservation and maintenance of soil and water resources. Reasoning by reference to field studies in other geographic areas because of the lack of detailed field studies of the responses of drainage basins to timber harvest in the Ozarks, Jacobson identifies the critical importance of the placing and design of logging roads and skid trails in reducing runoff and sedimentation. The effects of harvest activities diminish within 5 to 10 years if woody vegetation is allowed to grow back, whereas the effects of roads persist as long as 30 years (this would appear to lend support to the frequently heard call for application of Best Management Practices, which relate primarily to the placing and design of roads and skid trails). But there is so much that is not known about downstream effects of timber harvest in the midcontinental U.S., Jacobson concludes, that sustainability with respect to soil and water resources cannot be claimed without investment in long-term quantitative studies of drainage basins.

The final paper on elements of sustainability by Bernard Lewis discusses *Social and Economic Sustainability in the Missouri Ozarks*. Lewis offers a brief history of the evolving policy context for forest sustainability to indicate the extent to which human economic and social dimensions have increasingly been recognized as an indispensable aspect of sustainability. He then develops a framework for

addressing social and economic sustainability in the Ozarks, suggesting a dynamic "quality of life" model for community sustainability that expands beyond the socioeconomic indicators in Montreal Process criteria 6 and 7. He discusses what may be involved in building a diverse economy, establishing an appropriate institutional structure, fostering a vibrant level of civic engagement, and protecting and sustaining the vitality of cultural landscapes.

Part III, *Sustainable Silviculture in the Missouri Ozarks*, deals with an issue that has been highly contested in Missouri in recent decades, especially with respect to the management of public forests—the implications of even- or uneven-aged management of oak-hickory forests for sustainability. Silvicultural techniques in both national and state forests in Missouri shifted almost exclusively from uneven- to even-aged management in the 1960s, occasioning rising levels of concern among environmentalists about what they call clearcutting.

W. Dustin Walter and Paul S. Johnson review even-aged and uneven-aged silvicultural systems as applied both to Missouri oak forests and to central hardwood forests in general, concluding that, in Missouri at least, both methods may provide for the requisite regeneration of oak and thus for sustained yield of timber. But the controversy over clearcutting, they explain, illuminated the need to consider differing perspectives of forest values. In recent decades, the earlier paradigm of sustainable timber yield has been giving way to the more ecologically centered paradigm of sustainable forests.

Three staff members of Pioneer Forest—at 160,000 acres by far the largest privately owned forest in Missouri—discuss the past half-century of uneven-aged silviculture using single-tree selection harvest at Pioneer as a case study in sustainable forest management. During a half-century of silvicultural treatment aimed at restoring and maintaining the health and productivity of the forest and providing a continual flow of timber for harvest, the forest has been consistently monitored by a continuous forest inventory at 5-year intervals to assess the effects of management on the structure, condition, and species diversity of the forested landscape. Greg Iffrig, Clinton Trammel, and Terry Cunningham describe the single-tree selection system employed on the forest, discuss the methods and results of their continuous forest inventory, and then analyze the economic advantages of uneven-aged management. They conclude that single-tree selection not only is sustainable but also has decided ecological and economic benefits for forest landowners.

The three papers in the final section, part IV, deal with human factors in resource sustainability and their implications for public programs and policies. In his paper on *Trends in Demands for Missouri Forest Lands*, William Kurtz catalogs the array of demands placed on forest lands by individual owners and by society, many of which may be considered ecosystem services or amenity values. He summarizes the findings of recent surveys of landowner goals and behavior, most of which indicate that timber production is often not a primary goal, and presents a Missouri-based categorization of owners into four types—timber agriculturalist, timber conservationist, forest environmentalist, and range pragmatist. He concludes with a model of how owners make decisions about their land, noting the implications for the nature and timing of landowner education and financial incentive programs.

In chapter 11, sociologists Sandy Rikoon and Douglas Constance present results of their 1996 survey of Missouri citizen attitudes toward forest resources, a study that enabled them to analyze differences among regions and between urban and rural residents and forest owners and non-owners. Their findings indicate strong support for a holistic concept of sustainability that includes environmental, social, and economic objectives among all classes of respondents—urban, rural, and owner—suggesting that any proposal that favors one set of objectives over another would likely be met with opposition. Because respondents seemed less satisfied with the management of private forests than that of public forests, the authors suggest that Missourians would likely support appropriate programs to improve the management of private lands, although they caution that any attempt to impose strong regulatory mechanisms would be met with public conflict.

In the concluding chapter, *Chip Mills and Missouri Forests: A Case Study in Policy Development*, Bernard Lewis assesses implications of the deliberations of the Governor's

Advisory Committee on Chip Mills from November 1998 through July 2000 for an understanding of the policy development process in Missouri. He identifies two distinctly different perspectives on the issues evident among both committee members and citizens— that the mills would provide markets for low-quality timber and thus lead to healthier forests and that the mills would offer financial incentives for irresponsible harvesting. He then shows how these perspectives reflected underlying ideological orientations toward the role of government and the private sector—libertarian and communitarian—that impeded discussion and resolution of numerous issues, especially matters related to private property rights and government regulation. After analyzing implications of the existing information base and the quite different organizational cultures of the Missouri departments of conservation and natural resources, he suggests that the establishment of a permanent statewide forest resource council, as recommended by the committee, might help over time to resolve Missouri's vexing ideological and policy dilemmas.

* * *

Publication of this volume and support of the conference from which it originated were aided by the University of Missouri (MU) Environmental Affairs Council and Environmental Studies Program, the L-A-D Foundation of St. Louis, the Forestry Division of the Missouri Department of Conservation, the USDA Forest Service North Central Research Station, and various other individuals and groups. Cosponsors of the conference who contributed in-kind support include the Missouri Audubon Council, Missouri Coalition for the Environment, Missouri Department of Natural Resources, Missouri Forest Products Association, Missouri State Tree Farm Committee, MU School of Natural Resources, MU Environmental Sociology Working Group, Pioneer Forest, and Sierra Club—Ozark chapter.

In addition to the authors of papers in this volume, many of whom assisted in various ways, many other individuals assisted in planning the conference and an associated field trip to forest sites in the Ozarks, participated on conference panels or as field trip leaders, and commented on manuscripts prepared for this volume. They include Scott Banbury, David Bedan, Brian Brookshire, Marvin Brown, Leo Drey, John Dwyer, Paul Ellefson (conference keynote speaker from the University of Minnesota), Michael Fraser, Jeff Fulk, Tasia Gordon, James Guldin, D.K. Hirner, Daryl Hobbs, Sandra Hodge, Mike Hoffman, John and Connie Johnson, Tom Lange, Loren Leatherman, Eric Peters, John Powell, Carolyn Pufalt, Walter Schroeder, Jack Slusher, Steve Spencer, Albert Vogt, Douglas Wallace, Jan Weaver, and John Wood. The editor would like particularly to acknowledge the assistance of Lucy Burde in preparing the volume for publication.

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Missouri's Forest Resources—An Ecological Perspective

Tim A. Nigh[1]

INTRODUCTION

This paper provides an overview of Missouri's forest ecosystems as a basis for discussing forest sustainability. It has four major take-home themes.

Theme one: forests are more than trees. Trees are certainly the most prominent biological element of a forest and are often used to define forest types (e.g., oak-hickory forest). But forests are biologically diverse ecosystems composed of numerous other plant and animal species that interact with each other and the physical environment to capture and cycle water, energy, and nutrients. Even if one is focused on sustaining trees and the timber resource, it is important to recognize and maintain the many biological and physical components and processes of forest ecosystems. Forests are indeed more than trees.

Theme two: to sustain forests, we need to understand them in a historical context. To effectively understand the current forest resources and set future direction, we need to understand where they have come from. There are a wide variety of forest ecosystems in Missouri. They exhibit a diversity of composition and structure that has resulted from hundreds, even thousands of years of ecological processes acting upon them. By understanding these processes and the resulting patterns in historic forest ecosystems, we will have a better opportunity to work with nature rather than against her.

Theme three: to sustain forests, we need to think big. Many of the processes that influence forest ecosystems occur at scales larger than the stand or even the compartment. Phenomena like fragmentation, species dispersal, and disturbance regimes occur at scales larger than traditional management units. A 200-acre patch of forest in the middle of an agricultural landscape may be effectively isolated from dispersal and disturbance processes, and thus limited in its ability to sustain long-term diversity. Consequently, as we think about managing a stand or compartment, we need to think about its context in a larger sense. By doing so, local actions might fit better into the larger picture and complement overall forest sustainability.

Theme four: defining forest sustainability issues depends on what scale (or how big) we are thinking and where we are in the state. We need to understand that challenges and opportunities to manage and sustain the forest resources are not the same everywhere; one set of practices is not universally applicable. Issues surrounding forest sustainability vary with where you are and how big you are thinking. Forest sustainability in the till plains of northern Missouri is different from that in the heart of the Ozarks. At finer scales, a dry, rocky ridgetop on nutrient poor soils has different forest ecosystem potential than a flood plain with nutrient rich soils and plentiful water. Challenges regarding forest sustainability depend on where you are in the landscape.

MISSOURI'S PRESETTLEMENT FORESTS

Missouri is located in the center of the North American continent at the confluence of our Nation's largest rivers and at the crossroads of several major biomes. This central location, along with a diversity of physical landscapes and a varied climatic history, has provided Missouri with a wide array of native plant and animal species and ecosystems. This exceptional biodiversity includes more than 5,000 species of plants and at least 20,000 animals occurring in almost 200 recognized natural communities (Nigh *et al.* 1992). Missouri's biodiversity contains representatives of adjacent bioregions as well as species and communities unique to the state. Many of our native species are dependent on a wide variety of woodland and forest ecosystems that have evolved in our state through time.

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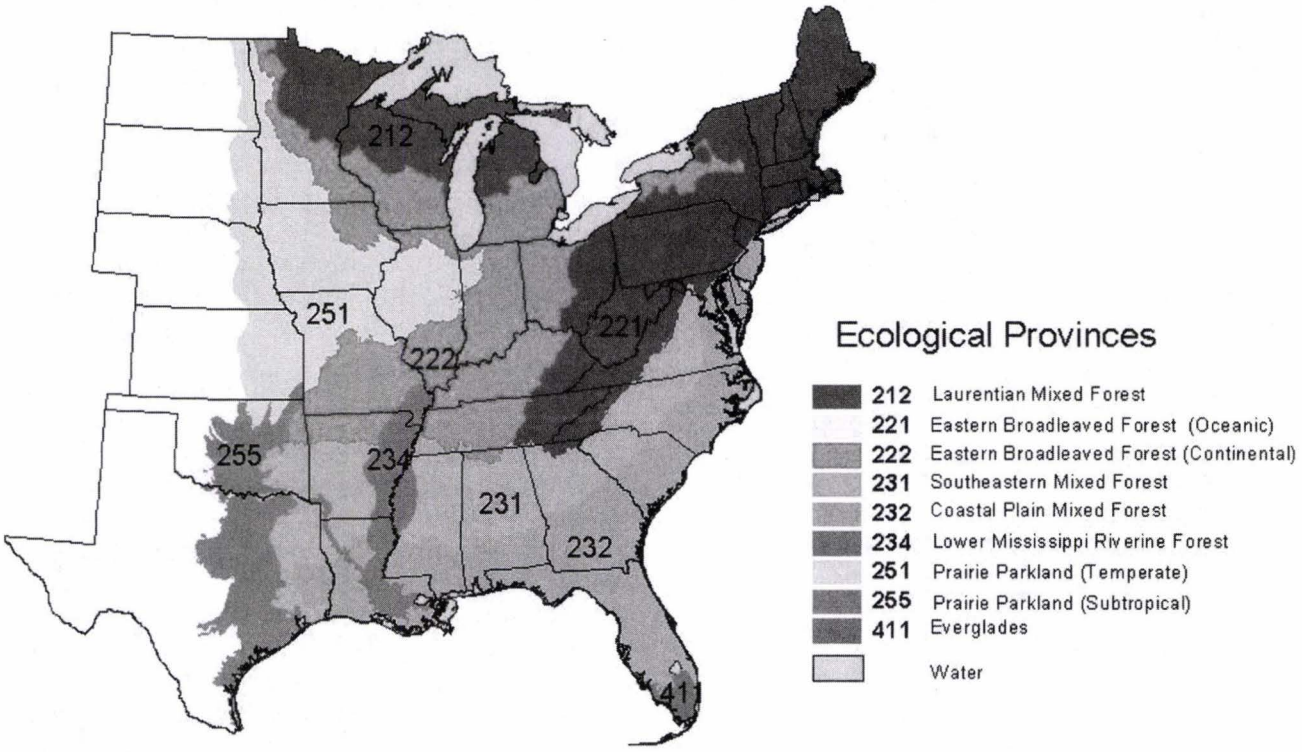

Figure 1.1—*Ecological provinces of the Eastern United States (Keys* et al. *1995).*

Figure 1.1 is a map of the Ecological Provinces of the Eastern United States (Keys *et al.* 1995). Missouri lies at the western edge of the Eastern Broadleaved Forest Province at a place where decreasing rainfall to the west supports primarily grasslands and increasing rainfall to the east supports primarily deciduous forests. Here, on the western edge of the province, it is drier and historically more fire prone than the rest of the eastern broadleaved forest. Under these conditions, the more drought- and fire-tolerant oaks dominate the forests. To the east, mixed-mesophytic forest species such as sugar maple, basswood, and elm increase in abundance.

Because of this location, it is reasonable to surmise that through time the interaction between grassland and forest has been quite dynamic, with periods of grassland encroaching into forest and forest encroaching into grassland. Missouri is in effect located at a highly dynamic grassland/forest edge. Studies of vegetation history using pollen cores bear this out (Delcourt *et al.* 1986).

There are various sources we can tap to pursue an understanding of what our forest resources were like prior to European settlement. One clue we can use is the original land survey notes. The General Land Office (GLO) survey was conducted in Missouri mainly between 1815 and 1840. The survey gridded the state into 6 x 6 mile townships, which were subdivided into 1 x 1 mile square sections. When the GLO grid was established, the surveyors walked the lines, documenting the land, vegetation, water, and human features of every one of those miles. In addition, at every section corner and quarter corner where trees were present, they identified at least two witness trees. These notes consequently serve as an excellent sample of what the vegetation was like at the time of settlement.

Walter Schroeder (1981) used the original land survey notes to map the original extent of prairie in Missouri (fig. 1.2). In creating the map, Schroeder mapped prairie only where the surveyors called that part of the line "prairie." According to this map, most of northern and western Missouri was originally tallgrass prairie. Prairie also extended into parts of the Ozarks, especially on the Springfield Plateau and on the higher, flatter interior Ozark landscapes. In these parts of the state, non-prairie "forest lands" were confined to the more rugged lands near the stream valleys.

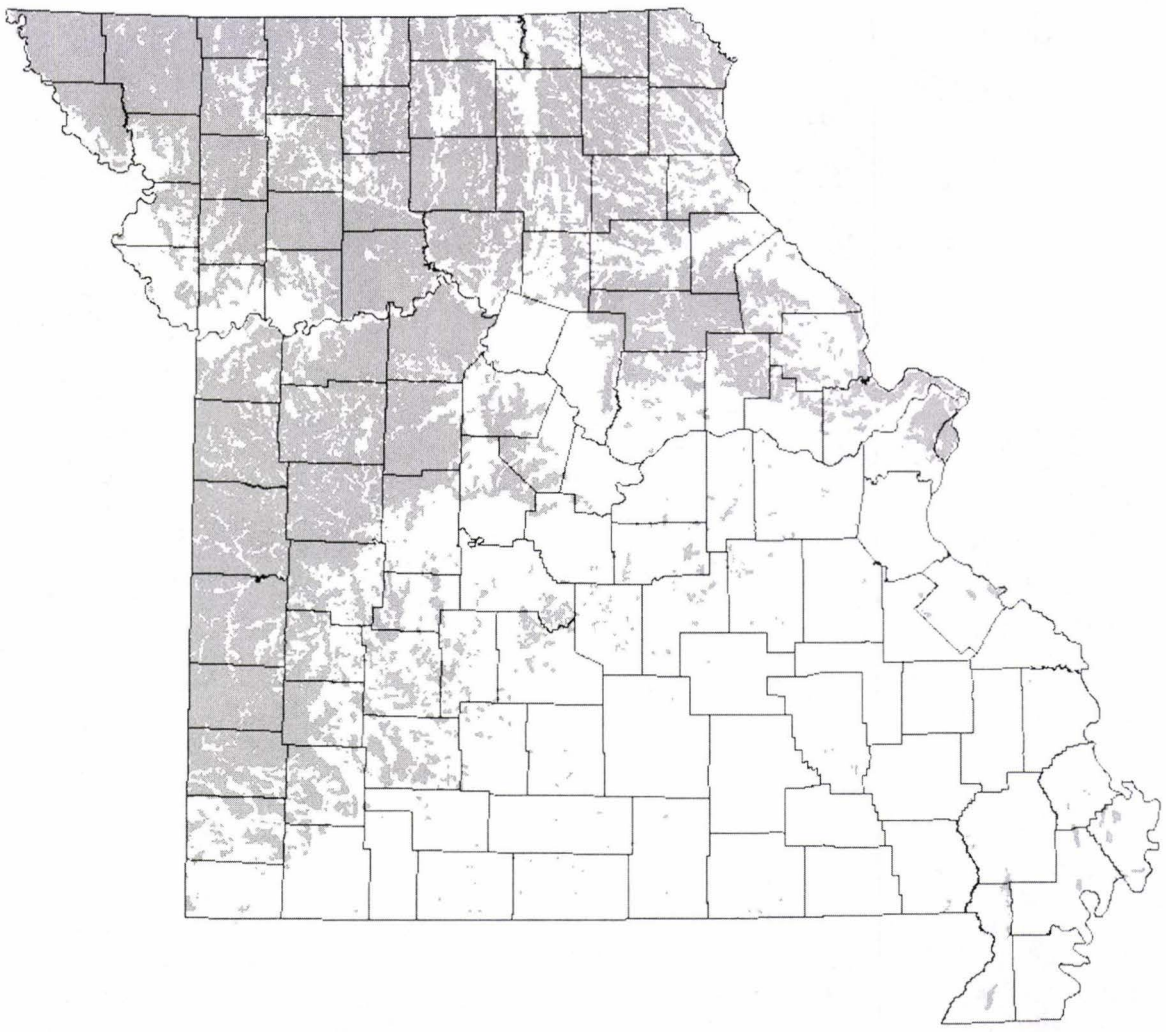

Figure 1.2—*Schroeder's (1981) Presettlement Prairie of Missouri.*

If approximately one-third of Missouri was prairie, was the rest forest? This has been a common misconception. As Schroeder read every mile of the notes, he recognized that the non-prairie lands were not simply forest. They ranged from wide open grassland with scattered trees, through savanna and open, park-like woodlands, to well-developed, dense forests. In fact, a majority of the timberlands appeared open and park-like.

Historical accounts also provide us with a glimpse of Missouri's historic forest resources. I want to share several historical accounts. (See Ladd 1991 and Nigh 1992 for more thorough information.)

Adair County was one of the most rugged and timbered landscapes in northern Missouri. In describing historic Adair County, Violette (1906) wrote:

> In the timbered portions of the county, there was absolutely no brush. The trees were very massive, and the ground underneath was covered with prairie grass. The massive trees, the prairie flowers and grass all combined to make this a truly beautiful and inviting land.

Even here, in one of the most rugged and timbered portions of northern Missouri, Violette described it as open and park-like with grass in the understory of the timbers. Many early descriptions of north Missouri described the timberlands this way.

A lot of people traveled the Booneslick trail in Missouri's early history, providing us with a view of the lands along the prairie-forest border between St. Louis and Booneslick. Brackenridge (1814) traversed the trail in

1811, and he wrote: "the country was alternating prairie and beautiful woods of tall oak, mulberry, honey locust, and perfectly open as though planted by art."

He also recognized the role of fire as well as the variation in forest density throughout the landscape: "Not withstanding the ravages of fire, the marks of which are everywhere to be seen, the woods were principally, hickory, ash and walnut, forming a forest tolerably close."

Traversing the route, it appears that the density of trees varied with landscape position, open timbers dominating the higher, flatter uplands and denser forest the lower, more rugged river hills.

Louis Houck was a railroad engineer in Cape Girardeau (fig. 1.3). Houck had a passion for reading and gaining an understanding of the early history of Missouri. In fact, he wrote a three-volume history of Missouri prior to statehood (Houck 1908). Most of the first volume describes the conditions of Missouri's landscape prior to settlement based on his extensive research of early writings. While Houck thoroughly documents the early forest conditions in the Ozarks, they can be summed up in one quote: "Open woods and a growth of wild prairie grasses and flowers filling the broad spaces between the trees. All the forests were free from undergrowth and open and park-like in appearance."

Figure 1.3—*Louis Houck.*

Henry Rowe Schoolcraft (fig. 1.4) traveled in Missouri in 1818 and 1819 and wrote in his journal every night (Schoolcraft 1821). He walked from Potosi west and southwest across the Ozarks to the White River region, and then up to the present location of Springfield, and then back to Potosi. Reading his journal, you can actually follow Schoolcraft and his companion along the way. Let me share a few of his observations.

While in the vicinity of Potosi, Schoolcraft painted a picture that contrasts with the densely timbered hillsides one would see there today:

> The mineral hills are invariably covered by a stunted growth of oaks, seldom found to grow higher than 30 feet, and 40 is the highest, seldom exceed a foot in diameter, and stand scattering. The whole country is covered in summer by a luxuriant growth of grass which hides the flinty aspect of the country and gives it a pleasing and picturesque appearance.

Schoolcraft left Potosi, walked across the headwaters of the Huzzah and Courtois Creeks, and went right through Indian Trail State Forest, describing most of this route as "open, rocky barrens." From the Salem area, he headed south toward the headwaters of the Current River. Before he dropped into the Current River Valley near Jerktail, he slept in an area he called "a prairie of little lakes." I think these were sinkhole ponds out in a prairie on the high flats near Jerktail. Then, after passing through "lofty forests of pine," Schoolcraft found a dense growth of timber in the rugged Current River Valley. This pattern of prairie and open oak woodlands on the high flat divides, pine woodlands on the valley edge,

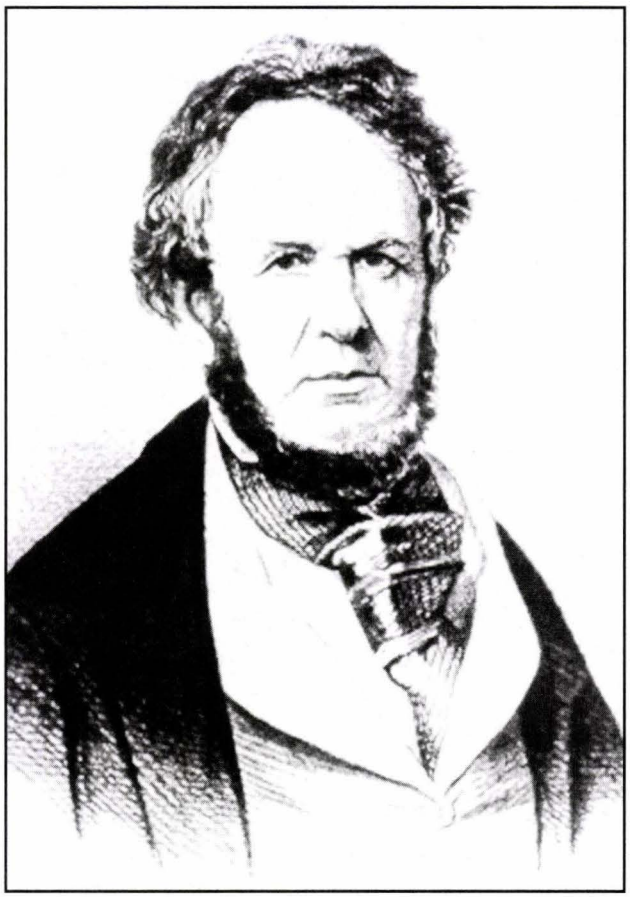

Figure 1.4—*Henry Rowe Schoolcraft.*

and well-developed forests in the rugged river hills repeats itself throughout his and other accounts of vegetation patterns in the Ozarks.

After climbing out of the Current River Valley in the vicinity of Raymondville, Schoolcraft actually saw a bear eating acorns in a post oak out in the middle of a prairie. He saw elk in the open woodlands near Cabool. As he dropped down to the North Fork of the White River, he again went through pine, then dense, mixed forests, and finally back up onto the "high oak prairies" on the other side. Schoolcraft later camped at the base of the Lower Pilot Knob in the Hercules Glades Wilderness. That night he wrote:

> The country we passed over yesterday after leaving the valley of the White River presented a character of unvaried sterility. Sometimes we cross patches of ground of considerable extent without trees or brush of any kind. Frequently these prairies occupied the tops of conical hills or extended ridges, while the intervening valleys were covered with oaks.

Here, he describes the original glade-woodland systems of the White River balds region. Again it was much more open than we would see there today.

Curtis Fletcher Marbut was a geologist and soil scientist in Missouri between 1880 and 1920 (fig. 1.5). He wrote *Soil Reconnaissance of the Ozark Region of Missouri and Arkansaw* (1911). Marbut tramped all over the Ozarks, digging holes and observing soil and vegetation patterns. His conclusion about the Ozarks was that:

> The greater part of the Ozark dome was up to the middle of the nineteenth century a region of open woods, large areas being almost treeless. Except for in the roughest land the timber growth was not dense enough in any way to hinder the growth of grass. The whole region and its vegetation was more closely allied to the western prairies than to the timber-covered Appalachians.

And, in fact, a lot of our "forest" flora is sun loving and more allied to the western plains than it is to the more shade-loving species of the Appalachians.

Figure 1.5—*Curtis Fletcher Marbut.*

Marbut also recognized the role of fire. He said: "the lack of undergrowth was, without doubt, wholly or principally due to the annual burning of the grass. When the annual fires were stopped, young timbers started up at once and developed with marked rapidity."

I agree with Marbut. Fire played a principal role in creating and maintaining this open, park-like condition. Fire would have burned into the timberlands, largely eliminating the understory, removing the leaf litter, allowing more sunlight to get to the forest floor, and promoting numerous grasses and wildflowers to develop there. The fires did not necessarily remove the canopy. In fact, a lot of the timbered areas in the Ozarks had a substantial forest canopy, but were open with an abundant ground flora maintained by fire. The native oaks and shortleaf pine, with thick bark and the ability to sprout after fire, were adapted to a disturbance regime that included fire of varying frequency and intensity.

Where did the fire come from? Numerous historical accounts recognize Native Americans as a principal ignition source, especially in eastern North America. "It was a common practice among Indians and other hunters to set the woods and prairies on fire" (Amos Stoddard 1812). Native Americans used fire as a tool to manage their landscape, driving game, promoting forage, enhancing travel and sight, and defending themselves.

Grazing by large, native herbivores also had to play a role in creating and maintaining these open timber conditions. Buffalo and elk were common in Missouri prior to settlement, and their influence on the woods would have been substantial as well. In flood-plain forest systems, we have to think about flooding as a significant disturbance in shaping bottomland forests. Besides flooding, other natural disturbances, such as fire, windthrow, ice storms, drought, and disease all played an essential role in creating and maintaining our native forest ecosystems.

The tremendous diversity provided by the intermingling of forest, woodland, and grassland ecosystems in historic Missouri supported an abundance of wildlife that impressed many early explorers. Houck wrote:

> In this favorite and park-like land, all animal life flourished. The clear and limpid waters were alive with fish, the air full of birds, the woods and prairies the haunt of wild and ferocious animals. The lordly bison roamed in great herds through the prairie.

Before settlement, Missouri was a tremendously diverse and vibrant landscape, with an exceptional biodiversity. Timbered ecosystems occupied about two-thirds of Missouri, but they represented a wide array of forest ecosystems from open bur oak or post oak barrens, through mixed oak and pine woodlands, to dense forests composed of oak and numerous mesophytic tree species. The diverse structure and composition of these timberlands resulted from a long evolution that included fire, flooding, grazing, and wind as important disturbances.

Of course, Europeans then arrived in Missouri, and during a period between 1880 and 1920, most of our original forests were harvested. Exhaustive timber harvest, coupled with extensive grazing and annual burning, left our forest resources in extremely poor condition by the 1930s. After 1930, the conservation era began. State and Federal natural resource agencies began to purchase and rehabilitate lands. Programs to educate landowners and regulate land management practices were widespread. And the land began to heal. Through these efforts, we have recovered many of the native forest systems and species that were teetering on the brink. But we still face a great challenge: on top of this history of abuse and subsequent conservation, we have altered the disturbance regimes that evolutionarily created and maintained the forest systems we are now trying to sustain.

CURRENT FOREST RESOURCES

Missouri currently has about 14 million acres of forested land. Of course, the composition, structure, and general condition of these forests vary widely. Challenges and opportunities to sustain forest resources are substantially different depending on where you are in the state. An ecologicial classification system can be used to recognize and describe differences in forest resource status and potential throughout the state.

An Ecological Classification System (ECS) is a framework for identifying and mapping ecological units of land at regional, landscape, and local levels. The Missouri ECS project has

been applying the USDA Forest Service approach to ecological land classification in Missouri (USDA Forest Service 1993, Nigh and Amelon 1996; Nigh and Schroeder 2002). Using this system, Missouri can be broken into four broad ecoregions or ecological sections: the Ozark Highlands, the Osage Plains, the Mississippi Alluvial Basin, and the Central Dissected Till Plains. Ecological sections are broken into subsections, subsections into landtype associations (LTAs or ecological landscapes), and LTAs into ecological landtypes (ELTs or ecological sites) and phases (ELTPs) based on integrating patterns in landform, geology, soils, and vegetation (fig. 1.6). The ECS is similar to Missouri's Natural Divisions and Sections (Thom and Wilson 1980) through the subsection level, but its strengths lie in the linkage to ecoregions nationally and to the finer landscape and site levels. This spatially hierarchical or nested framework allows one to describe and map ecosystems from broad ecoregions, through landscapes to local levels. I will use the system to provide some examples.

The Central Dissected Till Plain Section encompasses the glaciated plains of northern Missouri. In the past, prairie covered a majority of the region, while timbered areas were associated with more rugged lands near the river valleys. The timbered areas were largely savannas and open woodlands, with dense forests confined to the roughest or the lowest parts of the landscape.

Today, the region is an agricultural landscape with cropland and non-native, cool season grass pasture the dominant land uses. Forest resources are fragmented into numerous small patches of second-growth forest or invasive thickets of old field origin. Some large patches of timber remain in minor parts of the most rugged subsections, including the Missouri, Mississippi, and Chariton River Woodland/ Forest Hills Subsections (fig. 1.7).

The fragmentation of forest habitats has very important implications for forest interior breeding birds. Studies of forest fragments in the Till Plains have shown that breeding success in these small fragments is minimal (Gibbs and Faaborg 1990). In fact, they are acting as sinks, meaning that birds that originate in larger blocks of forest disperse out and attempt to reproduce unsuccessfully in these small fragments. Reproductive success is limited by nest predation by cowbirds and other edge-adapted predators.

The oak savannas and open park-like woodlands that were historically common in the Till Plains are now very rare. Old, original "wolf trees" can still be seen scattered throughout a sea of non-native forage grasses. Much of the existing forest is largely former savannas and open woodlands that have grown thick with invasive woody species and have lost their diverse ground flora. Bur oak and mixed oak woodlands containing swamp white oak and shellbark hickory, unique to the Till Plains of northern Missouri, are virtually absent. We have just recently begun to recognize and restore these ecosystems.

Despite their fragmented and somewhat degraded condition, forests in the Till Plains are some of the most productive and unique forest communities in the state. Many upland loess and till forest types are dominated by white oaks and red oaks that grow to exceptional size. In addition, diverse mixed hardwood forests are common on mesic slopes and coves in the river hills subsections. These mesic forests support a rich and unique ground flora assemblage.

From an economic standpoint, some of our most productive sites for a variety of species, including white and red oak, walnut, ash, hickory, and sugar maple occur on the rich Till Plain soils, offering outstanding opportunity for producing high-quality hardwood timber products. Management challenges include regenerating oak in the face of significant competition from sugar maple, hornbeam, and other prolific shade-tolerant species.

The Mississippi and Missouri Rivers flow through the Till Plains and into the Ozark Highlands; subsections recognize the flood plains of each river within each of these sections. In the Till Plains the valleys of both rivers are much broader, and surprisingly, bottomland prairie and marshes were originally the dominant vegetation cover. Riverfront forests of cottonwood, willow, and silver maple were an abundant forest type, with scattered mixed bottomland hardwood forests confined to the highest terraces. Within the Ozarks, riverfront and mixed bottomland hardwood forests shared dominance of the big river flood plains.

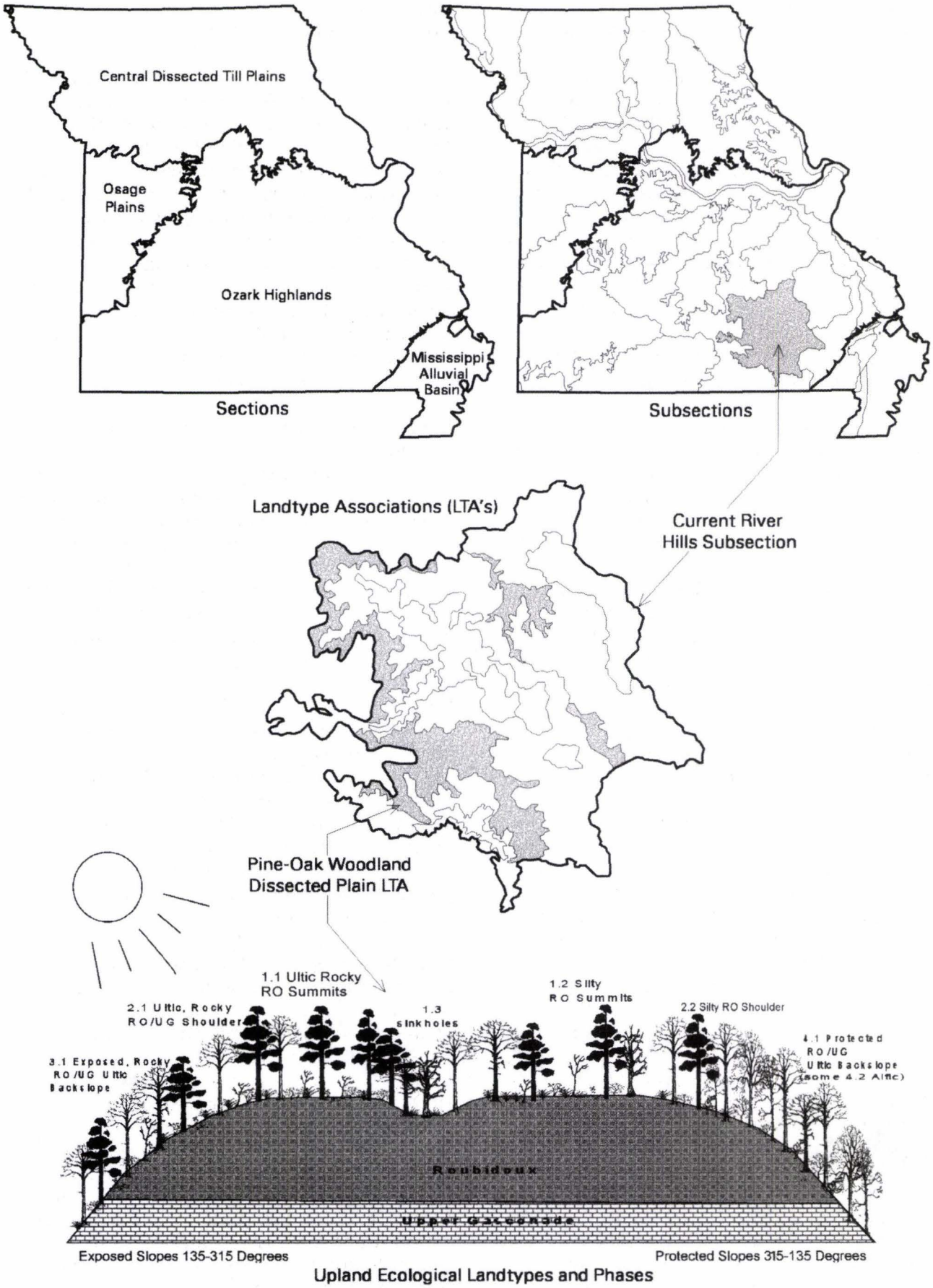

Figure 1.6—*ECS hierarchy in Missouri.*

Of course, nearly all of these flood plain forests have been cleared and converted to cropland. In addition, the natural hydrologic cycle has been drastically altered by levees, channelization, and drainage networks. Consequently, bottomland forests along the big rivers are perhaps our rarest and most poorly understood forest ecosystems. Recent acquisition of flood damaged land by State and Federal agencies is giving us substantial opportunity to restore these ecosystems, but recognition of the relationship of forest type to fluvial landform and hydrologic restoration will be necessary.

The Mississippi Alluvial Basin Section in southeastern Missouri's Bootheel region was originally an inaccessible wilderness of swamps, bottomland forests, and marshes. Many forest communities, including cypress-tupelo swamps and mixed bottomland hardwood forests of willow oak, overcup oak, sweetgum, pumpkin ash, water locust, and numerous other species were unique to this part of the state. Unique forest communities also occurred on Crowley's Ridge. The region was so wet and hard to traverse that the Bootheel was not substantially settled until the 1900s when extensive ditching and drainage of the area was accomplished. Today the region is 95 percent cropland. Only isolated remnants of the original forest ecosystems remain on some of the lowest wettest lands. Examples include Mingo National Wildlife Refuge and the Donaldsen Point Conservation Area, as well as several areas on Crowley's Ridge. Even these last vestiges of some of our rarest forest ecosystems suffer from hydrologic alterations and continual pressure to drain them. Again, little is understood about maintaining or restoring these forests.

The Ozark Highlands Section encompasses one of the largest contiguous blocks of forest in the central United States. While the extent and character of the forest vary with ecological subsection, some of the larger forest blocks are proving to be important source areas for successful reproduction of forest interior bird species (Clawson *et al.* 1997).

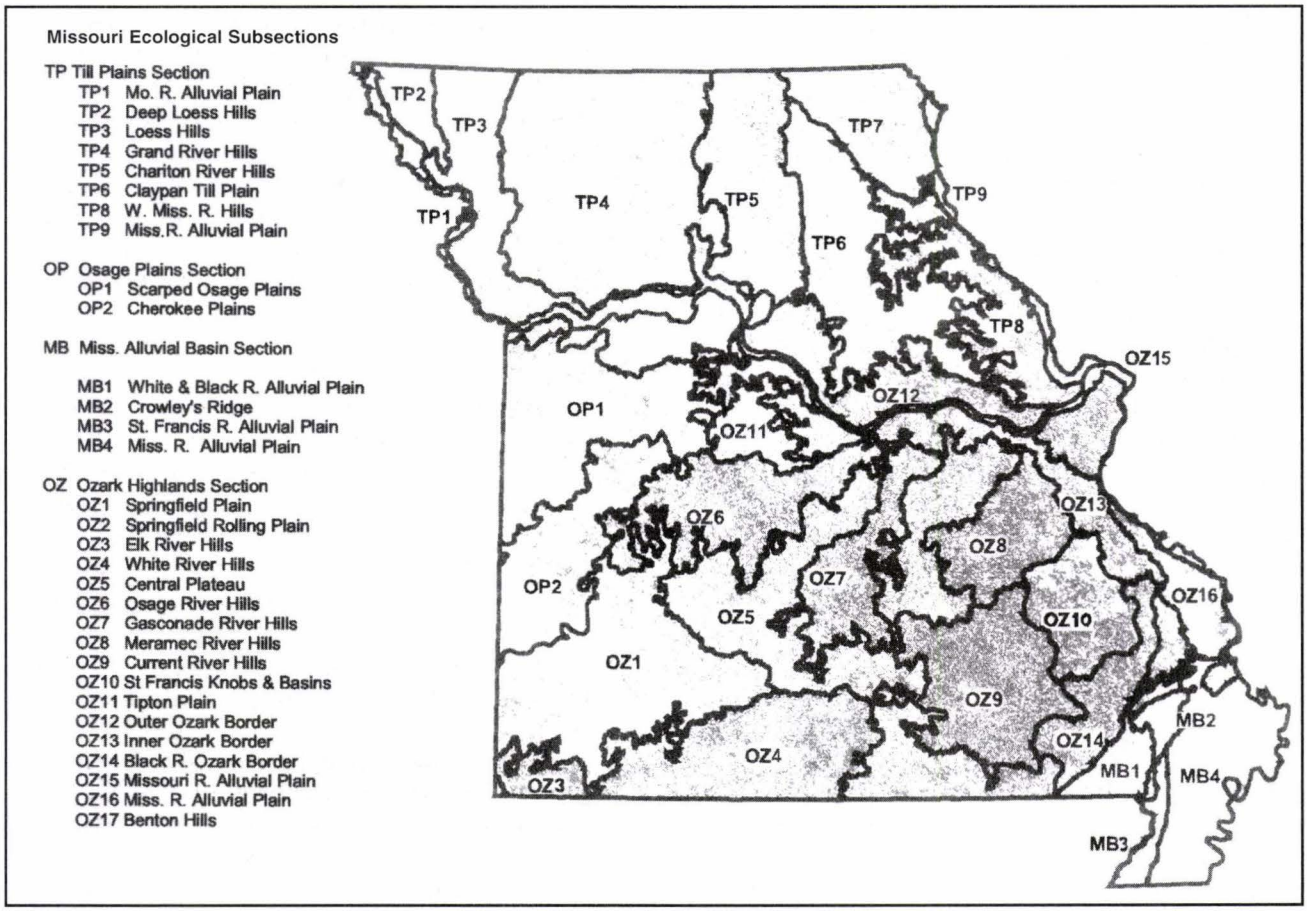

Figure 1.7—*Missouri ecological subsections and forest cover.*

Forest management issues in the Ozark Highlands vary with ecological subsection, and with the landscapes and sites within them. Let me provide a few examples.

The Central Plateau Subsection is the high, minimally eroded remnant of the Salem Plateau. Many Ozark highways (e.g., 63 and 54) and towns (e.g., Rolla, Houston, West Plains) are located on the Central Plateau. Originally a mosaic of post oak and post oak-black oak savanna and woodland with scattered prairie, the Central Plateau is today a mosaic of fescue pasture and small, fragmented woodlots. The post and black oak trees tend to be short and squat, because they grow on very poor, droughty soils with frequent fragipans. This is not the best timber resource from a site index standpoint. However, there are a lot of opportunities for short saw logs that support a substantial pallet industry.

Perhaps more importantly, there are opportunities to restore the native savanna and woodland ecosystems of the Central Plateau. Over the last decade, resource agencies have been learning a lot about putting fire back into landscapes like this. Results indicate that reintroduction of fire can quickly restore these ecosystems. Might there be an opportunity to provide native forage and timber resources while restoring the many values of native woodland ecosystems?

Many of the other subsections in the Ozarks encompass the hilly to rugged lands associated with the major stream valleys. **The Osage, Elk, White and Gasconade River Hills Subsections** of the western Ozarks are generally drier and have more substantial areas of shallow, poor, and droughty soils than the subsections to the east. Oak savannas and woodlands, as well as dolomite glade/woodland complexes, were common throughout these subsections. Most of the former glades, savannas, and open woodlands have grown up into dense forests and thickets with a shady, species poor understory. When we took fire out, as Marbut said, the timber sprang up rapidly, filling the spaces between the beautiful, open grown post and black oaks that dominated these lands. Today, we are putting fire back into many of these areas and getting tremendous results. Restoration sites like Bennett Springs Savanna in Dallas County exhibit over 300 native ground flora species while still maintaining a canopy of oaks. Many native species depend on this open, fire-prone condition, including many legumes and other species important to wildlife. Yet questions remain about our ability to sustain quality timber products while using fire as a management tool.

In contrast, forests of **the Inner and Outer Ozark Border Subsection**s along the Missouri and Mississippi Rivers have tremendously diverse and productive forest communities. They are often dominated by red and white oak, as well as numerous mixed hardwood species. The mesic forests of the Outer Border near Cape Girardeau even contain species like beech, magnolia, and other mesophytic species unique to that landscape.

The Current River Hills Subsection is the most contiguously forested subsection in Missouri. It encompasses the rolling to rugged hills associated with the Current, Black, and Eleven Point River drainages. A wide variety of forest communities within the Current River Hills can be described at the landscape (LTA) and site (ELT) levels.

The Pine-oak Woodland Dissected Plains LTA includes the flat to gently rolling divides between the rivers (fig. 1.8). Open shortleaf pine and shortleaf pine-oak woodlands once dominated the low base soils of this landscape. These systems supported a variety of unique species including red cockaded woodpecker and brown-headed nuthatch, now absent from Missouri. Some of the largest remaining blocks of pine and pine-oak forest occur along these dissected plains today. The same pine-oak woodland communities extended into the uplands of the adjacent Oak-Pine Woodland/Forest Hills LTA. Many of these sites have largely lost their pine component and are suffering die-back of mature scarlet and black oak. They have also lost their diverse ground flora. Recent efforts by State and Federal agencies to manage these woodlands using timber harvest and fire are resulting in the restoration of a diverse ground flora while yielding timber products.

The Current and Black River Oak Forest Breaks LTAs are the extremely rugged lands immediately adjacent the rivers in the center of these valleys. Historically densely forested, the Breaks landscapes have a wide variety of ecological landtypes that support a diversity of forest communities (fig. 1.9). They range from

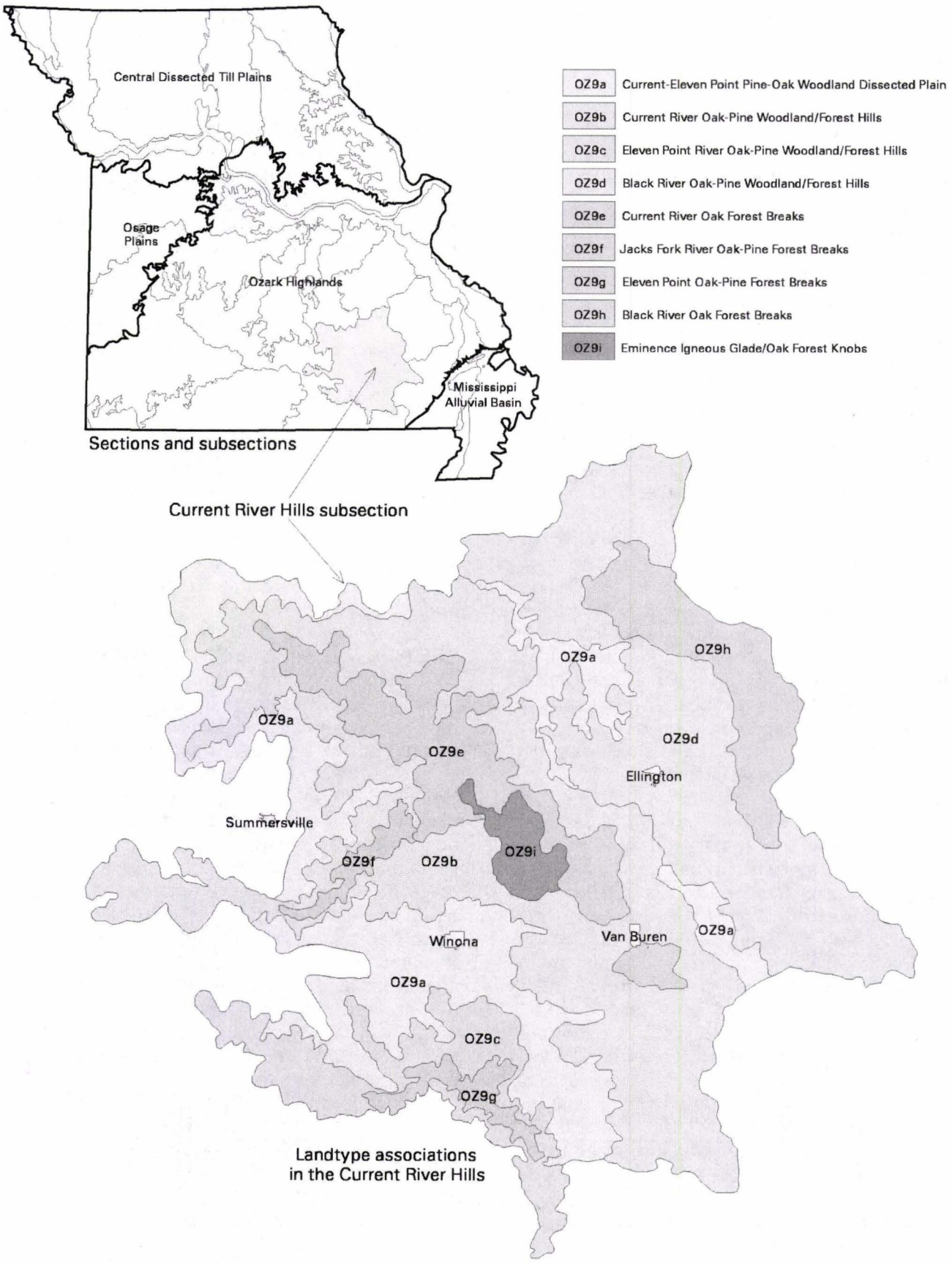

Figure 1.8.—*Landtype associations in the Current River Hills.*

oak-pine woodlands on exposed ridges and upper backslopes, through several mixed oak forest types, to mesic mixed hardwood forests on protected slopes and flood plains. Each has a unique set of management challenges and opportunities. Each has a special set of potential timber, wildlife, or natural history values that forest sustainability might address.

The variation in forest ecosystems exhibited within the Current River Hills can be well described by LTAs and ELTs in all ecological subsections. These, in turn, can be used to describe and recognize the diversity of management challenges and sustainability issues. The ECS, its sections, subsections, landtype associations, and ecological landtypes help us segregate and recognize the diversity of forest resource potentials at regional, landscape, and local levels.

SUMMARY AND CONCLUSIONS

Forest sustainability is a complex issue. Despite our focus on trees during forest inventory, assessment, and management—forests are more than trees. Rather, they are a complex suite of plants and animals interacting with each other and their environment to form ecosystems with multiple potential benefits to humankind. True sustainability requires that we recognize and strive to maintain or restore the diversity of forest ecosystems at regional, landscape, and local levels. An understanding of the historic structure, composition, and processes of forest ecosystems will help us better define and manage these systems. An ecological classification system provides an effective framework for describing the variety of forest ecosystems in Missouri and determining their future management needs.

Perhaps we might begin by using ECS and its concepts to develop an ecologically based inventory of forest resources in Missouri. From this inventory, we could identify the status of our current forest and woodland ecosystems and direct efforts toward sustaining those most in need. We could then identify the landscapes and sites most critical for achieving forest

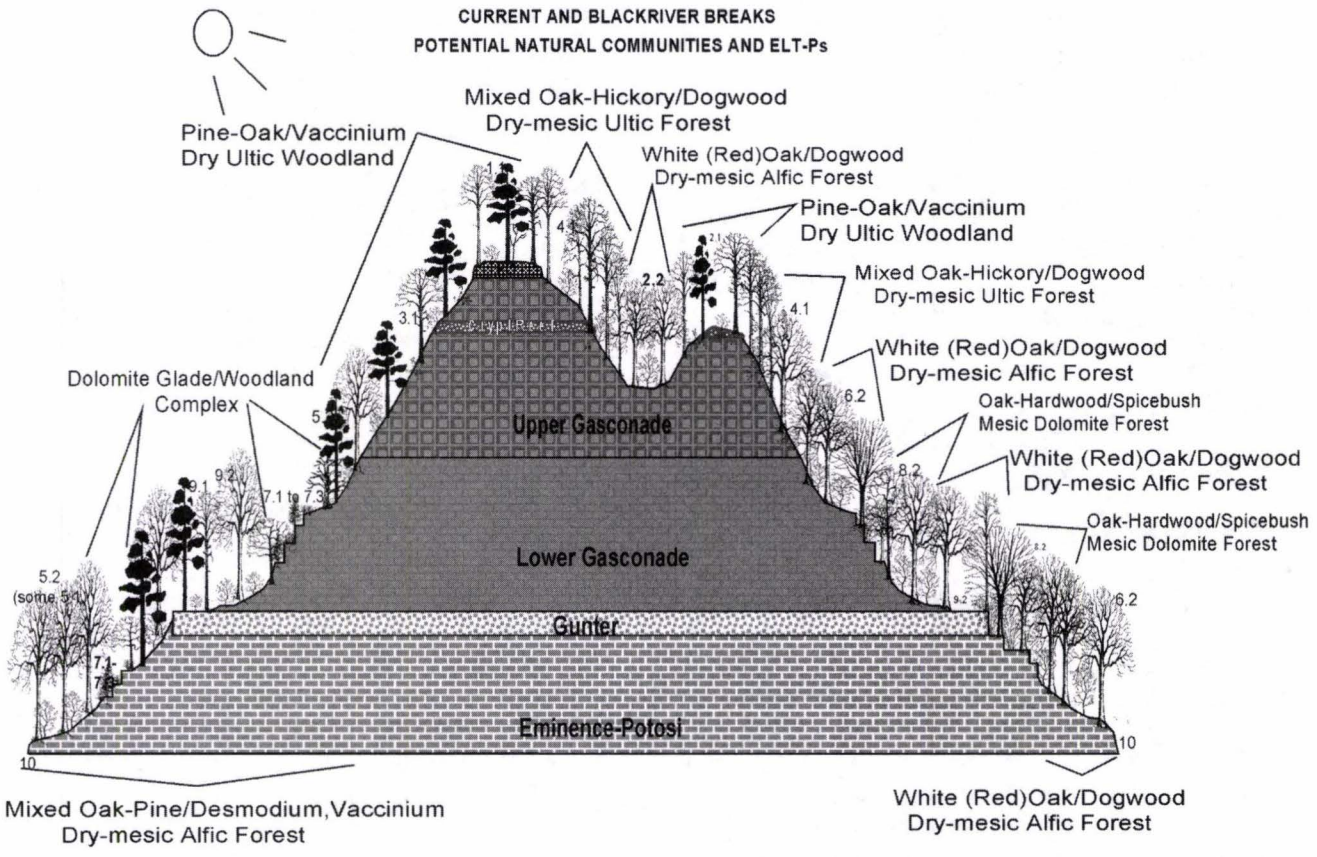

Figure 1.9—*Ecological landtype phases in the Current and Black River Breaks LTAs.*

ecosystem sustainability. Let's then develop and apply a wide variety of forest management techniques that promote and sustain the unique attributes of each of our forest ecosystems. Let's mimic natural disturbance regimes where we can. Let's move toward a more holistic approach to forest management that sustains the entire system, not just the trees: a system that integrates timber, wildlife, natural history, and human values into the forest sustainability equation.

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History of Missouri Forests and Forest Conservation

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The forests of Missouri have developed their social, economic, and ecological value through evolutionary change during the last 200 million years since the Ozark uplift when much of the future state was above sea level and available for colonization by a diverse array of plants and animals. For more than 10,000 years, Missouri's forests sheltered Native Americans who manipulated them principally through the use of fire to enhance their value for human sustenance. Then the forests provided much of the biotic capital that fueled more than two centuries of economic development by European Americans, suffering dramatic alteration in the process. And now they are being revisioned as a fundamental support for a more sustainable and satisfying life for future generations. This paper reviews the history of the last two centuries of forest exploitation, the slow pace of early efforts at conservation, and the revisioning process in which Missourians have been involved in recent decades in order to provide a basis for assessing the possibilities for and limitations on achieving sustainability.

In the extent of its forests, as in so much else, Missouri is middling among the 50 states, while in the diversity of its ecosystems it is outstanding. Though in presettlement times it shared with many of the eastern states a higher percentage of forest cover than the national average—approximately 70 percent forested as compared with 50 percent for the nation as a whole in 1600—today, Missouri at 32 percent forested is very close to the national average (fig. 2.1). Located at the center of the continent on the border between the oak-hickory woodlands of the East and the tallgrass prairies of the Great Plains, Missouri's forests exhibit ecotonal boundaries of certain species of the east and west and of the north and south. Missouri's geographic location at the junction of major biomes and of three great rivers, the historic fluctuations in its climate, its varied rock and soil types, and its dissected uplands

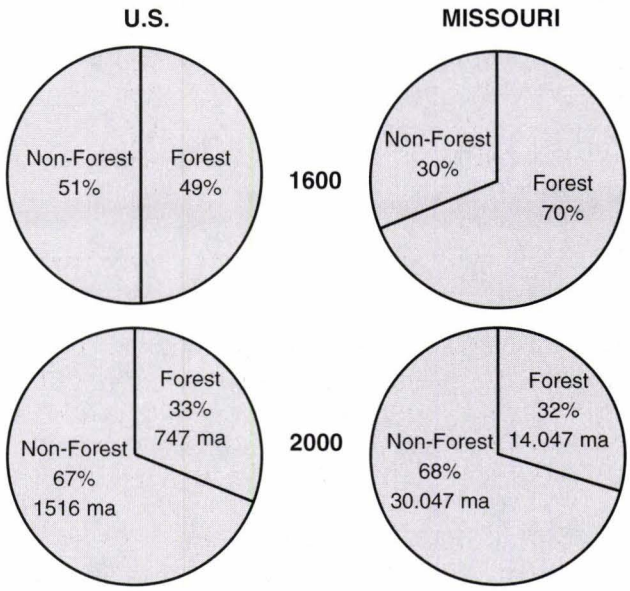

Figure 2.1—*Forests as a percent of land area, 1600 and 2000, U.S. and Missouri. Source: USDA Forest Service RPA Statistical Summary, July 2000 (1997 data).*

so long above sea level have given the state, especially its Ozark highlands, an uncharacteristically rich assemblage of flora and fauna.

Missouri today has a smaller proportion of its land in forests than many eastern states largely because so much of its land is suitable for agricultural crops and pasture. Indeed, most of the loss of forest cover has resulted not from timber harvest for market but rather from clearance for agriculture, cities, and other development; industrial logging, even of the most exploitative sort, did not ordinarily result in total land clearance. Of Missouri's 44.6 million acres, about 31.2 million acres were originally forested. Of that, about 12 million acres were cleared (in the language of the census, "improved") by 1910, particularly on the rolling plains of northern and western Missouri and along the rivers (table 2.1). Another 5.2 million acres of forest were lost to land conversion during the remainder of the 20th century including the southeastern lowlands and other low-lying areas requiring drainage, as well as uplands useful for pasture and land in the vicinity of burgeoning cities, leaving about 14 million acres of forest land today. Although some of the wood from agricultural clearing found its

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Table 2.1—*Amount of land cleared by decade, Missouri 1850-1910. Source: U.S. Census.*

Year	Million acres cleared
before 1850	2.9
1860	1.3
1870	0.8
1880	2.6
1890	1.6
1900	1.6
1910	1.2
Total	12

way to market, much was undoubtedly used locally for domestic fuel or building material or it was wasted; as such, it was a byproduct that was not ordinarily enumerated in official statistics (Cole 1970, Williams 1989: ch. 5, 11).

Unlike a number of eastern states, such as Massachusetts, Mississippi, or Wisconsin, in which significant acreage once cleared for agriculture has reverted to forest, Missouri's pattern of agricultural and forested lands, once established, has remained relatively stable. Today, Missouri has extensive forests (with interspersed grazing and small plot agriculture) in the Ozark and Ozark border regions amounting to about 11.33 million forested acres, with the heaviest concentration (67 percent of land forested) in the eastern Ozarks; the remaining half of the state included in the prairie region and the southeastern lowlands has only 2.67 million acres of forest, with the lowest concentration (6 percent) in the southeastern lowlands. The resultant tendency has been to focus discussions of forest history and policy on the Ozarks, even though the site quality of forested and potentially forested lands in the other regions of the state is often higher.

Perhaps the very word "forest" has been a misnomer for Missouri during much of its history, even or especially in the Ozarks. To this day, most Ozarkers describe their environs as "woods" or "timber," not forest. In Great Britain and elsewhere in Europe, from which their ancestors came, the word forest usually meant the King's land, unenclosed but bound by laws that excluded use by commoners. The *Oxford English Dictionary* offers, as its legal definition of forest, "A woodland district, usually belonging to the King, set apart for hunting wild beasts and game, etc...; having special laws and officers of its own." The applicable definition of wood is "A collection of trees growing more or less thickly together (esp. naturally, as distinguished from a *plantation*);" and timber denotes trees available for use as building material: "in *English law*, Trees growing upon land, and forming part of the freehold inheritance: embracing generally the oak, ash, and elm, of the age of 20 years or more; in particular districts, by local custom, including other trees, with various limitations as to age." Hence, woods and timber were available for use by ordinary people; the forest was not. In a place like the Missouri Ozarks, with a traditional lifestyle based on hunting, woodland grazing, and small plot agriculture as well as timber harvest, it is hardly surprising that people whose ancestors chafed under the rules of the King's forest in the old country would look with distrust on the very idea of a forest and the government forestry officials and university-trained professionals who purported to control it.

RISE AND DECLINE OF THE LOGGING INDUSTRY

Prior to the expansion of railroads after the Civil War, the impact of logging for domestic, market, and industrial use was local but in places severe. As early as 1797 the French commandant of New Bourbon, Pierre-Charles Delassus de Luzieres, proposed regulations to prohibit fires and to mandate using all downed timber before cutting any standing trees to conserve wood for heating and for the manufacture of salt and the smelting of lead. Records of colonial Ste. Genevieve include requests for concessions of pineries and large wooded tracts at ever-increasing distances from towns and mines, and accounts of officials and travelers indicate that wood was scarce and lands "barren" in the vicinity of the mines by the early 1800s (Schroeder 2002). Amos Stoddard (1812), who oversaw the transfer of Upper Louisiana to the United States, reported that the cost of pine lumber was "exorbitant" by 1804; and during his travels in the Ozarks in 1818-1819, Henry Rowe Schoolcraft (1819: 164) noted a number of sawmills on the Gasconade River at which pine lumber was cut for rafting to the St. Louis market. In the 1820s there were mills also on the Big Piney in Texas County. By the 1850s, when much of the Gasconade lumber had been cut, there were more than a dozen

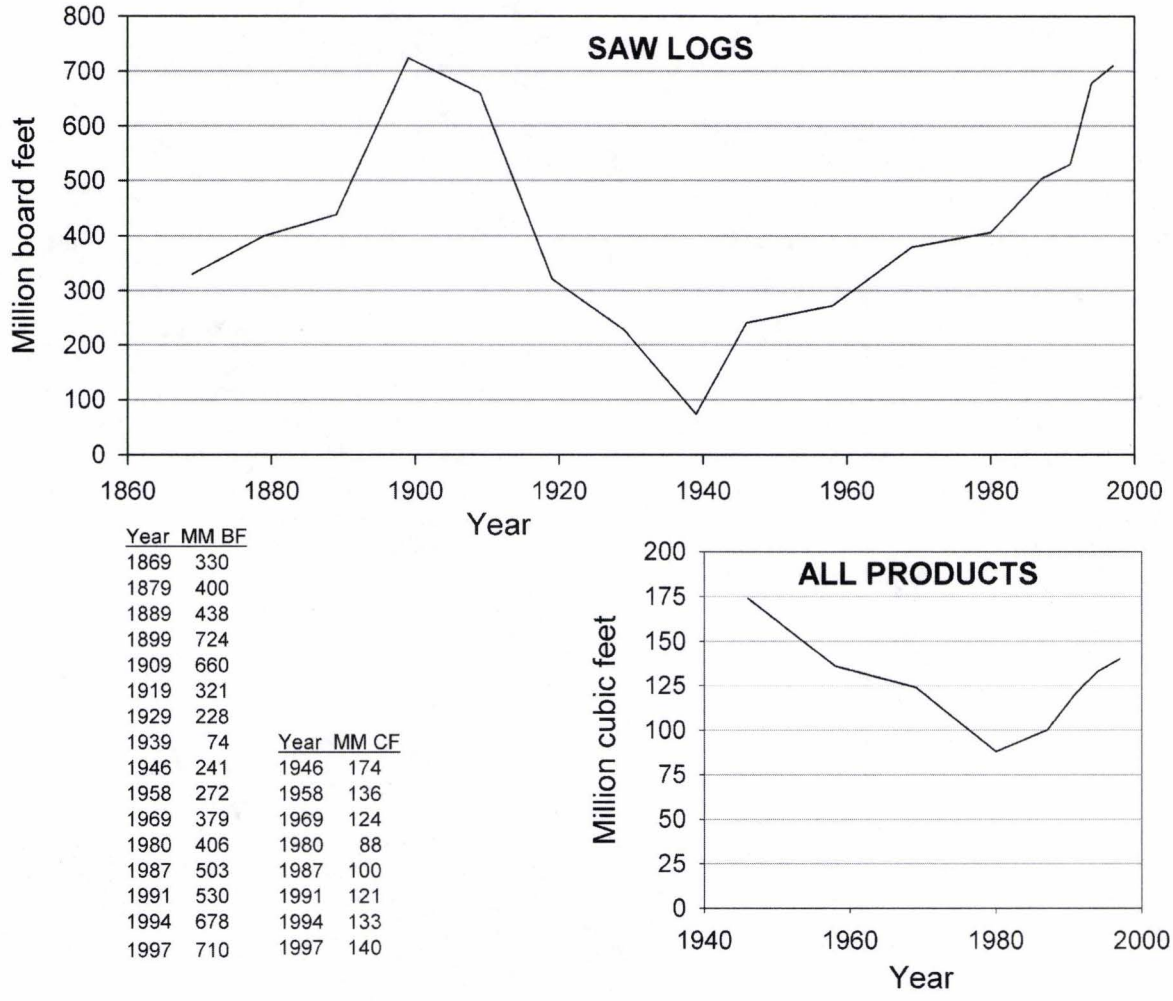
small mills in Ozark County near the Arkansas border (Sauer 1920a, 153). In mining regions of the southeastern Ozarks where shortleaf pine was processed into charcoal for the smelting of lead and iron, local succession shifted to oak and hickory which, fortuitously, were even better suited for charring; the Meramec Iron Works, for example, annually required the wood from 500 to 600 acres by the 1860s (Norris 1964: 8, 42-47).

By far the greatest detrimental impact of early woodcutting came from the insatiable demands of steamboats on the Mississippi and Missouri Rivers. The larger boats running by midcentury burned 50 to 75 cords of wood a day, roughly enough wood to build 10 to 15 frame houses, and by 1860 more than 700 steamboats regularly plied the waters in the vicinity of St. Louis. The drain for firing steamboat boilers was orders of magnitude more than that for building houses and barns, at least in the vicinity of the great rivers. Notes recorded by surveyors for the General Land Office during the 1820s-1840s contain numerous references to "cut off timber" in line descriptions on the flood plains. The extensive clearing of flood plain forests destabilized the banks of the rivers, causing the rivers to become much wider and more shallow and resulting in numerous steamboat wrecks and the eventual obliteration of most of the early French colonial river towns (Norris 1997).

The market for timber in the Midwest and out onto the Great Plains expanded greatly after the Civil War, when railroads dramatically increased their miles of track. After the first railroad reached across the state in 1859 and across the nation in 1869, track mileage in the United States nearly doubled each decade, reaching 357,000 miles by 1910. Railroads not only provided a means for transporting lumber from its source to markets in the rapidly growing and timber-deficient Plains States, but they also required an enormous amount of wood themselves for crossties, bridges, trestles, telegraph poles, fencing, and, especially in the early years, fuel. More than 2,500 ties alone were required per mile of track, and they needed to be replaced every 5 or 6 years (Olson 1971, Williams 1989: 344-52). M.G. Kern of St. Louis, author of the first technical professional paper of the new forestry division of the U.S. Department of Agriculture, *The Relation of Railroads to Forest Supplies and Forestry* (1887), calculated the annual drain for railroads at nearly 300,000 acres.

Missouri, situated at the boundary of the Great Plains, was fated to be a major supplier of wood for national development; it had the northernmost stands of southern shortleaf pine, prized as a building material, and the westernmost stands of white oak, the preferred species for crossties. Enterprising lumbermen from cutover areas in the East began investing in Ozark forests soon after the Civil War. O.H.P. Williams and his son-in-law E.B. Grandin of Pennsylvania purchased 30,000 acres of pineland in Carter County in 1871 for about $1 an acre; it would become the nucleus of the largest lumber firm in the Ozarks, the Missouri Lumber and Mining Company (Hill 1949). But most lands thus acquired in the 1860s and 1870s, often from settlers who had patented them from the federal government but could not pay the taxes, had to await the extension of railroads into the area in the late 1880s before much timber could profitably be cut for market. Though there had been sawmills and tie-hacking operations along the earliest railroads into the Ozarks—notably the St. Louis and Iron Mountain and the Kansas City, Fort Scott and Memphis—and along streams that could float logs or tie-rafts to railheads, timber production in Missouri shot up from around 400 million board feet (mbf) per year during 1870-1890 to a peak of more than 700 mbf in 1899 (fig. 2.2) after construction of new lines including the Current River Railroad and numerous logging tram lines into more remote areas (Stevens 1991: 71-77).

At the height of timber production in the Ozarks, the Missouri Lumber and Mining Company's plant at Grandin in Carter County, which employed up to 1,500 workers and had an annual capacity of 75 mbf a year, was said to be the largest sawmill in the nation. But company holdings of more than 300,000 acres in the vicinity were largely pined out by 1909, when operations shifted to a new mill at West Eminence in Shannon County. It was the quest for pine that fueled the Ozark timber boom, though by 1909 much of the pine was gone and hardwoods made up nearly three-fourths of the state's output. By 1920, the boom was over; annual production declined to around 300 million board feet, and Missouri, for several decades a major timber-producing area for the nation, now consumed more than



Year	MM BF
1869	330
1879	400
1889	438
1899	724
1909	660
1919	321
1929	228
1939	74
1946	241
1958	272
1969	379
1980	406
1987	503
1991	530
1994	678
1997	710

Year	MM CF
1946	174
1958	136
1969	124
1980	88
1987	100
1991	121
1994	133
1997	140

Figure 2.2—*Missouri timber production in selected years, 1860-2000: saw logs and all products. Saw log figures from 1869 to 1946 are from U.S. Census of Manufactures categories "sawed timber" or "lumber sawed," as reported in Steer (1948). For the depression years, Steer also includes "estimates" that are somewhat higher, e.g., 1929-260, 1939-296. Saw log figures from 1958 to 1997 are from USDA Resource Bulletins. Figures for timber production of all products in million cubic feet since 1946 are from Piva* et al. *(2000): Table 4. Fuelwood (but not residential) is included in totals for 1946-59 mcf, 1958-52 mcf, and 1969-25 mcf, but not thereafter.*

it produced (fig. 2.3). Shortleaf pine, which had covered some 6.6 million acres in the Ozarks, often in association with oak, was largely depleted and succeeded by scrub oak and other hardwoods (which, unlike pine, sprout from the stump and tolerate shade); today, Missouri has only about 600,000 acres of pine or oak-pine stands (Hahn and Spencer 1991: 32). The large lumber companies, which in heavily timbered counties had owned as much as half of the land, formed real estate firms to sell off their holdings to unsuspecting buyers, often in small parcels of 10 or 20 acres, or simply stopped paying taxes on the land (Rafferty 1980: ch. 11).

Hardwood logging in various regions of the state was more attenuated than the boom in pine logging. In the spectacular swamp forests of the southeastern lowlands, the peak of industrial logging for cypress, tupelo, and ash came slightly later than in the Ozarks, 1900-1920, though it began with the earliest railroads in the 1870s and continued, largely as a function of land clearance for intensified agriculture, until the 1970s, when less than 100,000 acres of forest remained (table 2.2, Korte and Fredrickson 1977). In the Ozarks after the boom, production shifted to small operations, including individual farmers, who hacked ties and cut wood from highgraded

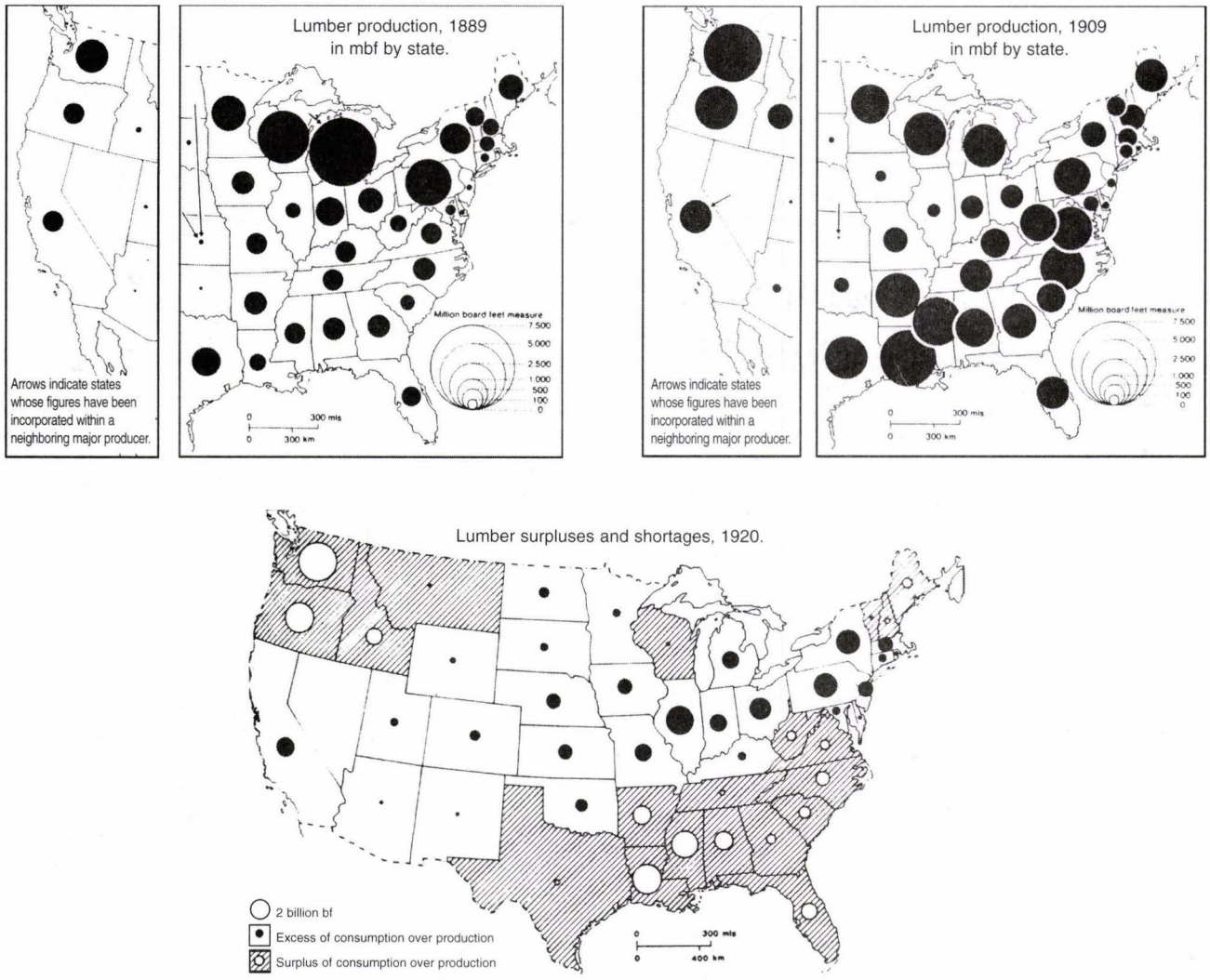


Figure 2.3—*Lumber production, 1889 and 1909, by state. Lumber surplus and shortage, 1920, by state. Source: Williams 1989: figs. 7.2, 7.3, 13.2.*

stands for stave bolts, charcoal, and firewood. Production slowed dramatically by the depression thirties, though in inaccessible areas there were still isolated stands of old growth, some of which remain to this day. And in the coal-mining areas that cover much of northern and western Missouri, farmers cut hardwoods for mine timbers as well as for railroad ties and farm fencing, buildings, and fuel throughout the first half of the 20th century (Wilson 1987).

During the boom years in the Ozarks in the late 1880s and the 1890s, population had doubled or tripled in most of the logging counties, by 1900 reaching levels that would remain fairly stable until about 1970 (fig. 2.4). With the influx of population came increased livestock and land clearing for agriculture. One category of livestock, however, had already increased dramatically by 1880: free-ranging hogs (Jacobson and Primm 1997). Open-range cattle and hogs had been ubiquitous since early settlement, as noted by Schoolcraft during his travels in the Ozarks (1819: 34):

> The farmer here encloses no meadows—cuts no hay.—The luxuriant growth of grass in the woods affords ample range for his cattle and horses, and they are constantly kept fat. Hogs also are suffered to run at large, and in the fall are killed from the woods; I

Table 2.2—*Decline of Missouri's southeastern lowland forest, 1870-1975. Source: Korte and Fredrickson 1977: Table 1.*

Interval	Influencing factors	Acres lost	Percent loss	
			Interval	Cumulative total
Before 1870	State and Federal Swamp Acts	300,000	12.5	12.5
1870-1880	Lumbering, railroads	115,000	4.8	17.3
1880-1890	Lumbering, railroads	142,000	5.9	23.2
1890-1900	Agriculture, drainage financed by long-term bonds	162,000	6.8	30.0
1900-1910	Lumbering, dipper dredge developed, Little River Drainage District formed	270,000	11.3	41.3
1910-1920	Lumbering	325,000	13.5	54.8
1920-1930	Cotton production	209,000	8.7	63.5
1930-1940	Depression, cotton production	133,000	5.5	69.0
1940-1950	World War II, agriculture subsidy, government assisted drainage, soybeans	216,000	9.0	78.0
1950-1960	Agriculture mechanization, drought, increased use of synthetic fibers, soybeans	61,000	2.5	80.5
1960-1970	Large farm equipment, expanding agricultural market, rapid population increase	237,000	9.9	90.4
1970-1975	Larger farms and fields, larger equipment, high soybean prices	132,000*	5.5	95.9
Total loss		2,302,000		95.9
	Forest acres remaining in 1975			
Total	98,000 or 4.1 percent of original 2.4 million acres			
Total in blocks of 1,000 acres or more	27,000 or 1.1 percent of original 2.4 million acres			

*Acres lost derived by deducting total forest left (as determined by aerial reconnaissance) and losses from all other periods from total lowland forest area before clearing.

> have seen no fatter pork than what has been killed in this way. There is, perhaps, no country in the world, where cattle and hogs can be raised with so little trouble and expense as here; and this is an advantage this country possesses which is likely to be permanent; for the country will never admit of a dense population.

Hogs could be extraordinarily prolific, a sow farrowing several times a year with up to 12 piglets per litter, though in semiwild populations fewer survived. Historians have noted the huge amounts of land required by free-ranging livestock and the damage livestock could cause by selective foraging and rooting, changing plant succession to less desirable, often exotic, species and interfering with forest reproduction. In certain regions of the South, forest-reared hogs came to be called "piney-woods rooters" in reference to their habit of devouring the tender roots of smaller pines (Cronon 1983: 135-150, Silver 1990: 174-180). Though little scholarly work has been done on free-ranging hogs and cattle in Missouri, the sheer numbers of these animals must surely have been a factor in the degradation of Ozark forests.

After the boom, the industry-augmented population remained to subsist as well as they could on small farms in the cutovers. They lived off their small fields of corn, their open range hogs and cattle, the fish and game that remained, and the meager income they could secure by selling wood from the cutovers. But the value of the remaining wood was low, game populations were nearly nonexistent after decades of relentless hunting for

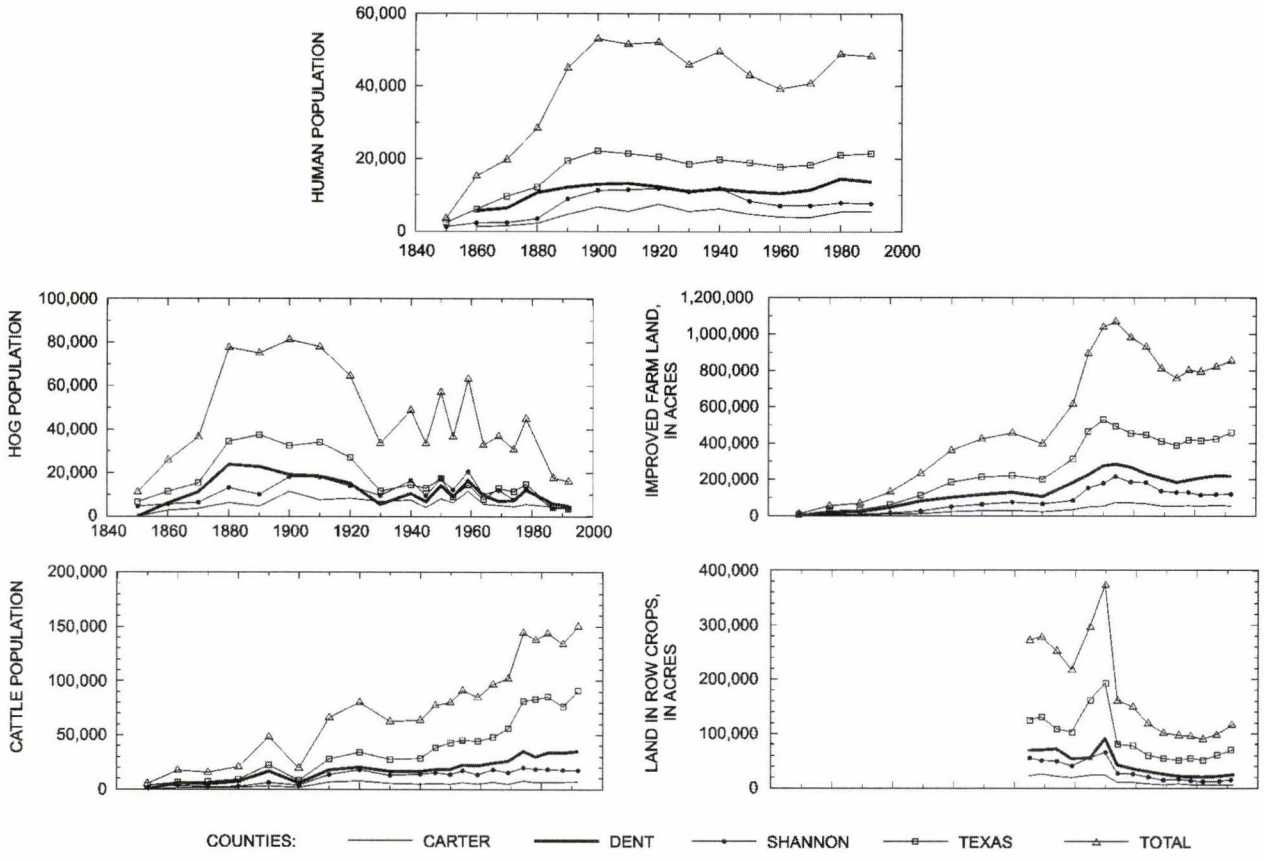


Figure 2.4—*Human population, hog population, cattle population, improved farmland in acres, and land in row crops in acres, 1850-1992, for certain Ozark counties. Source: Jacobson (this volume), fig. 5.5.*

market, fish catches dwindled in disturbed streams (Callison 1953: 13-15), corn yields were meager on the thin soils, and the degraded forest range could no longer support as many cattle and hogs. Carl Sauer, who was to become the pre-eminent American geographer of the 20th century, described ecological changes in the Ozarks of his native Missouri in his doctoral dissertation:

> Most of the range is very poor, especially for cattle. The grass-covered hills of the early days have been replaced for the most part by a dense growth of oak sprouts. The ceasing of grass fires, the clearing of smooth land, and the overgrazing of the remaining area have caused the famous bluestem pasture grass of the early days to become nearly extinct (Sauer 1920a: 185).

Hearkening back to ancient European custom long practiced in the American South from which many of the Ozark settlers came, farmers increasingly fired the woods in an effort to retard the sprouts and stimulate grasses for their animals—and, some said, to retard chiggers, ticks, and snakes (Pyne 1982: 143-155, Guyette 1995). The practice of annual woodsburning further degraded the soils and inhibited forest reproduction.

WHY WAS CONSERVATION SO SLOW TO DEVELOP IN MISSOURI?

It was in this context of economic stagnation in the Ozark cutovers in the 1920s that Missourians first seriously began to contemplate the need for forest conservation. Having just completed the most comprehensive study ever done of the Ozarks, Carl Sauer (1920b: 226) focused the issue:

> It is probably no exaggeration to estimate that fully half of the Ozarks can never be good for anything except the growth of trees. It is not growing good trees now and soon will be virtually non-productive. Missouri is facing the idleness of a fourth of its total area

> without so much as a forestry office in the state to take notice of the situation.

Missouri came relatively late to a commitment to forest conservation, not developing a permanent institutional structure until the 1930s. In part this was because the destruction of its forests came somewhat later than in New England, the Mid-Atlantic region, the Lake States, and parts of the South, but many states in those areas had begun to develop forestry programs decades earlier. Missouri's tardiness in developing public forestry can be attributed, in large part, to the political culture of the Ozark region, many of whose people had a profound distrust of government and preferred to be left alone (Hammar 1935).

Although the state as a whole was slow in awakening to the need for forest management, several Missourians played leadership roles nationally in the 19th century in making the case for conservation. After George Perkins Marsh of Vermont, in his celebrated *Man and Nature* (1864), sounded a warning about the unintended consequences of the destruction of forests, the Reverend Frederick Starr of St. Louis wrote a comprehensive analysis of forest problems for the first annual report of the newly established U.S. Department of Agriculture. In an argument that would frequently be borrowed by other conservationists, Starr (1866: 211) averred:

> Among the things which are most fundamental to a nation's material growth and prosperity, we name these four—cheap bread, cheap houses, cheap fuel and cheap transportation for passengers and freights...; and this question of wood enters largely and constantly into each one of these four great departments of industry and living.

He went on to make a case for government involvement, especially through the new Department of Agriculture, in education of forest landowners, silvicultural research under American conditions, and development of forestry incentives, proposing in particular incentives to plant trees on the prairies. The much-abused Timber Culture Act of 1873 was one notable congressional response.

Another Missourian, Carl Schurz, who served as Secretary of the Interior, tried valiantly to find ways to prevent timber theft from the public domain under his jurisdiction, issuing a circular in 1877 that gave responsibility for protection of public lands to agents appointed by the General Land Office rather than to local land agents. When the first head of the newly established Division of Forestry within the Department of Agriculture, Franklin Hough, submitted a series of reports based on inadequate statistics, Schurz, who was responsible also for the U.S. census, arranged for the appointment of Charles Sargent, professor of arboriculture at Harvard, to undertake a special study for the 1880 census on the distribution and value of forests, a monumental report (1884) that could provide an objective, authoritative basis for future legislation (Williams 1989: 376, 397).

Yet another Missourian who came to prominence nationally in forest conservation was the state's leading lumberman, John Barber White of Kansas City, general manager of the Missouri Lumber and Mining Company. Like many leading lumbermen from major firms, White was willing to cooperate with the advocates of forest conservation even as to the federal reservation of forests in the West, in order to stabilize chaotic markets and reduce competition (Robbins 1982: 10-12). In a major reorientation in its public land policies, which up to that time had emphasized disposal of the public domain to private ownership, Congress in 1891 authorized the President to withdraw forested lands from the public domain for permanent retention as national forest reserves; in 1905, these reserves were transferred to the newly established Forest Service in the U.S. Department of Agriculture, where the first Chief, Gifford Pinchot, developed a strong institutional structure for professional management by trained foresters. Each of the new forest reserves and proposed national forests was hotly contested, with advocates for free enterprise and local economic development pitted against local and national conservation interests. For a lumberman like White, who was operating in a region where the public domain had long since passed into private hands and hence there was no possibility of national forests, the more conservative management of publicly held forests in the West could actually be viewed more as a boon to stabilize chaotic markets than as a threat to

his own free enterprise. In 1905, when President Theodore Roosevelt appointed him to investigate exploitative lumbering on the Cass Lake Indian Reservation in Minnesota, White recommended withholding the lands from private use. Roosevelt then appointed him to the forestry section of the National Conservation Commission, and in 1909 the Governor of Missouri appointed him as a delegate to the first National Conservation Congress, which he served as chairman of the executive committee and then as president.

But for all his leadership at the national level—including advocacy of government planting of commercial forests, a yield tax on harvested timber, and elimination of waste through the grading of lumber and better harvesting practices—White proved unwilling or unable to practice forestry on his own lands. Whether because of unfavorable tax policies, timber poaching, woodsburning, and free-ranging hogs or because of the ready availability of new forest lands in Louisiana and elsewhere, White sold his Missouri holdings as soon as they were cut over and abandoned the milltowns he had created (Hill 1949, Galloway 1961).

Missouri's early conservation leaders were from St. Louis and Kansas City—Schurz from Germany, White from New York—and like many others of their heritage they had a more favorable view of the role of government in conservation than the southern stock who predominated in the Ozarks and elsewhere in rural Missouri and dominated the state legislature. Daniel Elazar (1966, 1994), who has mapped the dominant political cultures of the United States by state, classified Missouri as individualistic-traditionalistic, with democratic, market-based individualism characteristic of the Germans and English who settled the Middle Atlantic States slightly dominating the more traditionalistic culture of the South with its anti-bureaucratic bent and focus on maintaining the existing social order. But perhaps no state better than Missouri illustrates his further point that states are a mosaic of political cultures reflecting the various streams of population and history of development in different regions and locales. The Ozarks and many other parts of rural Missouri were settled by population streams out of the South who were far less receptive to progressive ideas of orderly government and institutionalized conservation than were Germans and Yankees from the middle states or the more communitarian, moralistic migrants from New England who settled in the big cities and in parts of north Missouri. And, at least until the Supreme Court decision in 1962 that forced periodic legislative reapportionment under the principle "one man, one vote," the rural traditionalists held sway in the Missouri General Assembly.

Missouri's governors during the high tide of conservation consciousness in the Progressive Era, Joseph Folk (1905-9) and Herbert Hadley (1909-13), were from St. Louis and Kansas City, respectively, and both made efforts to develop an institutional framework for forestry in Missouri similar to that being developed at the federal level and in many states. But even here there was a difference, with Hadley, who grew up in more moralistic Kansas, willing to go farther in the development of governmental institutions for conservation than Folk, who was raised in Tennessee. Joseph Folk attended Theodore Roosevelt's celebrated Conference of Governors in the White House in May 1908, the first major national meeting to rouse conservation sentiment among political leaders, and was inspired to announce his intent to appoint a Missouri forestry commission (Folk 1909). Folk's four-man commission, who served without pay, proposed legislation to establish a state forestry division, but the rural-dominated general assembly was not interested (von Schrenck 1909). By this time, well over half of the other states, mostly in New England and the upper Midwest, had begun the acquisition of state forests or established some sort of forestry agency (Chapman 1909).

Governor Hadley, who came into office advocating an array of progressive conservation programs including forestry and waterways commissions and a state park system, unsuccessfully sought legislative support in 1909 for a bill authorizing Missouri to obtain land for conservation purposes, arguing that owners of large cutover tracts in the Ozarks would be glad to deed them to the state for reforestation (Hadley 1909). The one conservation measure that won legislative support in the Hadley era was a fish and game law in 1909 that outlawed the commercial game trade and channeled license revenues into a game protection fund managed by a state fish and game commissioner. Then in 1917, the general assembly authorized 5 percent of all fish and game license fees to be set aside in a state park fund, an amount that proved inadequate to

begin acquiring land (Flader 1992). But repeated efforts to establish a division of forestry or to authorize acquisition of land for state forests failed to get legislative approval.

Nationally funded conservation programs were of even less interest to Missouri. After the U.S. Congress in 1911 passed the Weeks Act, which authorized purchase of land for national forests in the eastern states, where there was no longer any public domain, a reconnaissance team from the Forest Service visited the Missouri Ozarks in 1914 and recommended two areas for federal acquisition. One area totaling 468,700 acres was in the St. Francois Mountains region in St. Francois, Iron, Madison, Wayne, and Reynolds Counties; the other totaling 585,900 acres was at the headwaters of the Current River above Van Buren, in Carter, Shannon, Texas, and Dent Counties (Hall 1914a-b, DP f272). But the Weeks Act required passage of an enabling act by the state, and the Missouri general assembly was not interested. One can imagine the small farmers of the Ozarks who grazed their livestock on open range, grandmawed timber, and repeatedly fired the woods being deeply resistant to the notion of government foresters controlling their use of the land. Nor was the general assembly, ever attuned to the voices of the locals, enticed by the prospect of federal matching funds under the Weeks Act for forest fire protection, though forestry agencies in 23 states, mostly in the eastern half of the country, were taking advantage of the program by 1920 (Steen 1976: 130).

The only agency in Missouri to develop an institutional basis for forestry during the Progressive Era was the state university in Columbia. When it was designated in 1870 as the land grant college for Missouri under terms of the Morrill Act of 1862, the university began offering lectures on forestry in its agricultural curriculum. But training in forestry never amounted to more than a few courses and those were often horticultural, focused on fruit growing; eminent viticulturist George Husmann, for example, was professor of pomology and forestry from 1878 to 1881. In 1907, three new courses in forestry appeared in the catalog; and then in 1911, perhaps following recommendations in a study of *Forest Conditions of the Ozark Region of Missouri* by Samuel J. Record of the Forest Service, the board of curators appointed the university's first professor of forestry, John Arden Ferguson. A graduate of the Yale Forest School, the premier professional program in the nation (established in 1901 with an endowment from the father of Gifford Pinchot), Ferguson won authorization from the curators in 1912 for a 5-year curiculum in forestry leading to the master's degree. After he resigned in 1913 to head the forestry program at Pennsylvania State, the university appointed Frederick Dunlap, graduate of another prestigious forestry program at Cornell University, to head the fledgling two-man department. At the time, only Iowa and Nebraska of the states surrounding Missouri offered degree programs in forestry, in addition to a number of institutions in the East and upper Midwest (Rodgers 1951: ch. 7, Westveld 1970: 1-8).

Dunlap persuaded the curators to transfer responsibility for administration of the state's remaining unsold agricultural college lands in the Ozarks—about 50,000 acres of Missouri's original Morrill grant of 330,000 acres—to the department of forestry in 1914 for reconnaissance, protection, and forestry training (DP f4-5). He conducted a summer field camp (f10) and surveyed the lands, recommending retention for forestry purposes of 14,661 acres in Ripley, Pulaski, Crawford, and Phelps Counties and an additional 10,081 acres of forested lands in Butler and Wayne Counties that held promise of iron ore (f59). But the curators in 1920 ordered that all lands except those with potential mineral resources be placed on the market for sale and that the department of forestry be abolished and Dunlap terminated effective September 1, 1921 (f76). There was no official explanation for this dramatic reversal of policy save reference by the board's secretary to "lack of demand for instruction in forestry," but there are hints here and there in Dunlap's own papers that it might have had to do with agitation in the state legislature for sale of the lands, power struggles between the forestry program and the college of agriculture, and perhaps Dunlap's own role in advocating the removal of the university president (DP f59, 66, 87). The university's forestry program so proudly begun at the high tide of progressivism in Missouri fizzled to nothing by 1921, having awarded 17 degrees. The university would not again offer even a pre-forestry curriculum until 1936, and it would be 1946 before it resumed a bachelor's degree program in forestry (Westveld 1970: 8-9).

THE LIMITS OF INDUSTRIAL LEADERSHIP

As Dunlap faced the loss of his program and position at the university, coming after more than a decade of frustration in efforts to win legislative support for state forestry (including introduction of at least 10 different bills in the general assembly), he began discussions with forest industry executives and consultants about the desirability of forming a statewide organization to lead a more concerted effort to establish a state program. His principal partner in this effort was an old colleague, Dr. Hermann von Schrenck of St. Louis, one of America's first forest pathologists. Von Schrenck had become head of the U.S. Department of Agriculture's Bureau of Plant Industry laboratory in St. Louis after earning his Ph.D. from Washington University in 1898 and subsequently became chief of the Division of Forest Products in the Bureau of Forestry. He had simultaneously lectured on plant diseases at the Shaw School of Botany and the Yale Forest School and published several pioneering tracts on tree diseases and timber decay before devoting his time increasingly to his career as a consulting timber engineer for several railroads and the National Lumber Manufacturer's Association (Rodgers 1951: 348-50). He had also served on Missouri's short-lived state forestry commission and authored its 1909 report recommending a state board of forestry. Among others involved in discussions leading to a new statewide organization were W.P. Gruner of Gruner Lumber Co., St. Louis; John Himmelberger of Himmelberger-Harrison Lumber Co., Cape Girardeau; R.B. White of Exchange Sawmill Sales Co., Kansas City; and J.W. Fristoe of T.J. Moss Tie Co., St. Louis.

The new Missouri Forestry Association was formally organized at a dinner in St. Louis in December 1921 cosponsored by the Lumberman's Exchange of St. Louis and the Tie and Timber Division of the St. Louis Chamber of Commerce. St. Louis had become the main crosstie market in the nation by World War I (Williams 1989: 349), and the firms involved in ties and other hardwood products, which in many cases still had sizable holdings in the Ozarks, were more committed to cutting rotations than the larger pine firms had been; hence they could benefit from tax reform, fire prevention, reforestation, citizen education, and other efforts of a state program. Though most of the officers and the financial support of the new Missouri Forestry Association came from the lumber industry (including von Schrenck, president, and Fristoe and Gruner, vice presidents), the group realized the desirability of broadening the base of its membership to include horticulturists, sportsmen, club women, and other civic leaders. Marie Turner Harvey of the Missouri Federation of Women's Clubs was elected a vice president, and Frederick Dunlap, now a consulting forester, coordinated activities of the association from his post as secretary (DP f81).

The Missouri Forestry Association was founded in the midst of an intense national debate over federal policy concerning private forests, a debate that engaged the entire forest fraternity. On one side was the former Chief of the Forest Service, Gifford Pinchot, who argued for mandatory federal regulation of timber cutting on private lands in addition to public ownership, and who regarded most state action as piecemeal and inadequate (Pinchot 1920: DP f71). On the other side were his successors as Chief, Henry Graves and William Greeley, who favored encouragement of state programs, initially including regulation, and federal/state cooperation on fire protection, reforestation, and tax reform (Steen 1976: 176-89). The tide was turning in the direction of state action, with 30 states enacting some type of forestry legislation during 1921 alone, leaving only a handful of states, Missouri among them, with no state forestry administration whatever (Anon. 1922). The industrial leaders of the Missouri Forestry Association opposed regulation at any level, but they supported a state forestry board to encourage the practice of forestry on private land. The association opposed the creation of national forests in Missouri and saw only a very limited role for state forests as demonstration areas.

In spite of MFA's considerable efforts, a welter of contending interests in Missouri prevented passage of forestry legislation during the biennial legislative session in 1923. Unlike MFA, recreational interests, including an active new state division of the Izaak Walton League and a new Outdoor League of America organized in St. Louis, promoted all types of public lands including national forests, state forests, state parks, and game refuges in Missouri, and they supported comprehensive conservation legislation that would combine the various functions. Some chambers of commerce also supported public lands for tourism development. William Hirth of the Missouri Farmers Association and

others in the state's powerful farm bloc distrusted scientific forestry and especially the forest industry, while Ozark farmers feared for their customary practices of open range grazing and firing of the woods. The only conservation legislation that passed was a measure to increase the annual transfer to the state park fund from 5 to 25 percent of fish and game license fees, enabling the Governor to begin to acquire land for state parks. Frederick Dunlap, still out of a job and probably more knowledgeable about forested land in the Ozarks than anyone in the state, was engaged to assist in evaluating tracts for possible purchase. More than a decade later, some of the parklands thus acquired would become the nucleus of a system of Missouri state forests (DP; Flader 1992).

In 1924, the national debate about forest policy was resolved—for the remainder of the 20th century, as it would turn out—against regulation and in favor of federal/state cooperation. The Clarke-McNary Act, passed that year, made matching funds available to qualified state forestry agencies for fire protection, nurseries, and reforestation. Missouri now had more incentive than ever before to create a state forestry program. With several bills again competing in the general assembly, the Missouri Forestry Association decided to seek support from William Hirth and the farm bloc. Giving up their dream of an independent state board of forestry, they agreed to accept a bill making the board of agriculture responsible for forestry. The bill provided for a state forester, but no staff for work in the woods and no authorization for state forests or for roadside tree planting. As Dunlap put it, it "merely carries on at State expense about the same work that has been done for 4 years by this Association" (DP f142; f143-46). When the Governor threatened to veto the bill owing to lack of funds to make it effective, the Missouri Forestry Association apparently agreed to provide the funds itself. After submitting a forestry policy and program to guide the work, the MFA council voted to contribute $5,000 annually to the forestry work of the State Board of Agriculture and $750 in matching funds for farm forestry extension by the college of agriculture at Columbia under the Clarke-McNary Act (DP f276; OM 1925-26, 823). Frederick Dunlap was appointed as state forester and half-time as extension forester.

Dunlap's position with university extension was terminated by the board of curators after only 1 year, but his role as state forester continued for 4 more years. In 1929, the general assembly actually appropriated funds to support his operation, thus relieving the MFA of its financial obligation; but state support would last only a single biennium. During his years as state forester, Dunlap concentrated on two programs, prevention of wildfire and planting of farm timber, both of which were eligible for matching grants under the Clarke-McNary Act (Dunlap 1930). Convinced that wildfire, mostly set by locals, was the greatest impediment to production of a forest crop of economic value, he decided the solution was to organize local communities for the control of their own fire. Accordingly, he hired Paul M. Dunn as district forester and stationed him in the central Ozarks near Ellington, where the state with Dunlap's help had acquired Deer Run State Park, some 5,000 forested acres. To extend his work to farmers in agricultural regions of northern and western Missouri, Dunlap started a nursery near Jefferson City and began planting demonstration farm timber patches, an activity to which he personally devoted nearly half of his time (OM 1927-28: 663-4, 1929-30: 817-18). And he continued to advise private landowners, much as he earlier (as MFA secretary) advised Rose Wilder Lane, who inquired about growing black walnut—the highest value tree in Missouri—on her elderly parents' Rocky Ridge Farm near Mansfield, where agricultural operations would no longer pay taxes and upkeep (DP f131; Lane's mother was Laura Ingalls Wilder, who had not yet begun to write her *Little House* books).

The prospects for conservation on the ground in Missouri as of about 1930 were perhaps most fully and incisively assessed in the course of a game survey of the state by Aldo Leopold. A Yale-trained forester who had left a distinguished career in the Forest Service to conduct surveys of the potential for game management and restoration in the eight North Central States funded by the Sporting Arms and Ammunition Manufacturer's Institute, Leopold traveled extensively throughout Missouri in winter 1929-30, observing conditions and talking with more than 125 sportsmen, scientists, officials, and farmers. He took a broad view of conservation, assessing the state's geographical and biotic diversity, the nature of its soils, trends in land use, institutional structures for conservation, and the attitudes of its citizens.

Like Dunlap, Leopold was essentially optimistic about the prospects for conservation in Missouri in spite of the paucity of action to date. Though Missouri was virtually alone among the states he visited in having no national forests, no state forests, and no university forestry programs, the state had some 14 million acres of forests and another 3 million acres reverting to forest through abandonment of farms. Intensification of agriculture, which was generally detrimental to wildlife, had not progressed as far or as fast in Missouri as in neighboring states, and in the Ozarks Leopold actually viewed the conversion of scattered tracts to fenced pasture or plowland as potentially favorable to wildlife. Missouri was notorious for woodsburning, he acknowledged, but in his view most people burned in self defense to prevent unexpected conflagrations set by others; with further agricultural development, there would be less burning. The pressing needs in Missouri were for public purchase of forest lands—he especially favored acquisition of major acreage in the Irish Wilderness, where wild turkey populations might be restored—and for a much more active state program of research, demonstration, and education aimed at changing public attitudes and private behavior concerning the use of private land. He particularly recommended establishment of a non-political commission with full authority for administration of conservation programs, including forestry (Leopold 1930).

But the country was even then sinking into the deepest depression in American history. Funding for Missouri's small office of state forester dried up entirely in 1931, all work ceased, and Frederick Dunlap and Paul Dunn left the state to seek employment elsewhere. Dunlap's final annual report, in sharp contrast to his earlier upbeat assessments, revealed a bitter sense of frustration about the prospects for forestry in Missouri, deeming fire control "impossible" as long as Ozarkers kept burning the woods (Callison 1953, 96; Benac 1998). The state's forest industry, like that nationally, had gone into steep decline in the late 1920s, and the Missouri Forestry Association was no longer a force, if indeed it even continued to exist. With chambers of commerce promoting public forests and with former Governor Arthur Hyde, now U.S. Secretary of Agriculture and member of the National Forest Reservation Commission, urging the state to take advantage of congressional appropriations for forests under the Weeks Act (Hyde 1929), the Missouri General Assembly in 1929 at long last passed an enabling act authorizing federal purchase of forest land in the state; but an amendment rendered it moot by limiting acquisition to no more than 2,000 acres per county. Then a new "National Forest Reserve Association of Crawford, Dent, Iron, Reynolds, and Washington Counties," formed by local businessmen and public officials to promote establishment of a national forest, finally succeeded in winning legislative authorization in 1933 for up to 25,000 acres per county—a limitation later that year revised to 100,000 acres and subsequently removed entirely—and the Forest Service quickly established eight purchase units in the Ozarks and began land acquisition (MNFA).

THE NEW DEAL IMPETUS TO PUBLIC FORESTS

Missouri's shift to acquiescence in federal forests was in part a recognition of depression-induced necessity made more appealing by a major infusion of funds for federal acquisition and development of forest land. In the early days of Franklin Roosevelt's New Deal, the Forest Service submitted a massive *National Plan for American Forestry*, known as the Copeland Report, which signaled a shift of policy emphasis from private to public forests. Though private owners held 80 percent of the commercial forest land nationwide, they expended only 10 percent of the "constructive effort" for conservation and they were responsible for "practically all of the major forest problems," the report said. To correct this imbalance, the plan recommended public ownership of fully *half* the nation's forest land; the report proposed federal purchase of 134 million acres of cutover and tax-delinquent land, with another 90 million acres to be purchased by the states, and advocated regulation of private cutting as a quid pro quo for public assistance including fire protection on the remaining land (U.S. Cong. 1933: 76, ix; Steen 1976: 199f). Though nowhere near this much acreage would be purchased and the Forest Service would not win the regulatory authority it sought, Roosevelt's New Deal would result in the purchase of some 8 million additional acres of national forests in the eastern states, including 1.3 million acres in Missouri. These purchases were coordinated with another New Deal program dear to Roosevelt's heart, the Civilian Conservation Corps, which provided employment to young men to plant trees,

construct roads and buildings, and in other ways to develop public lands.

Even before acquisition of substantial blocks for the newly authorized national forests in Missouri, the state took advantage of the CCC and other New Deal work relief programs to develop its considerable acreage of state parks. In his annual report for 1936, game and fish commissioner Wilbur Buford, who served also as state coordinator for all federal conservation funds, estimated that more than $25 million in improvements had been placed in Missouri through federal Emergency Conservation Work. This included nine CCC camps supervised by the National Park Service working on recreation development on state park land (amounting to more than 70,000 acres in 23 units, including three new federally acquired recreation demonstration areas slated for eventual transfer to the state), three CCC camps supervised by the Forest Service working on reforestation and fire control on state park land acquired primarily as forest game refuges (Indian Trail, Deer Run, and Meramec), more than 20 camps supervised by the Soil Conservation Service whose erosion control work benefited wildlife in northern Missouri, and a variety of Works Progress Administration and other work relief camps and projects. In addition, CCC crews were already at work on reforestation, road building, and fire control on more than 750,000 acres already acquired in the eight national forest purchase units (Buford 1936). Missouri qualified for all this federal aid by spending less than $1.5 million in all land acquisition, development, and operational costs since it had begun acquiring public lands in 1924 (MSPB 1939: 28). It is likely that no other state—certainly no other state in the Midwest—could match Missouri in the amount of federal conservation expenditure on state lands leveraged by such a paucity of state expenditure.

To qualify for continued federal funding under the various New Deal relief programs, states were required to institute comprehensive planning. With a majority of Missouri's rural-dominated legislature traditionally averse to the whole notion of planning and to anything that smacked of federal control, Missouri might well have missed out on much of the New Deal largesse had it not been for a strong tradition of urban planning in Kansas City and St. Louis that could quickly be brought to the service of the state. At the instigation of the Missouri State Planning Association, a citizens group headed by Judge Harry S. Truman of Independence, Governor Park in December 1933 appointed a Missouri State Planning Board, and the board secured the services of planning consultants Harland Bartholomew of St. Louis and S. Herbert Hare of Kansas City to direct the work of the technical staff in preparing reports (MSPB 1943). Perhaps taking its cue from the Copeland Report's recommendation that half the forests of the country be in public ownership, the state in 1934 recommended to the National Planning Board that 8 million of Missouri's 15.5 million acres of forest land be publicly owned, 7 million in national forests and 1 million in state forests (NPB). This goal of 8 million acres of Missouri forest land in public ownership would reappear in official documents well into the 1940s. The state planning board substantiated its ambitious goal for public ownership and other federal aid programs in reports issued in 1935 that included a map detailing land use problem areas (fig. 2.5; MSPB 1935: 2). Cursory examination of the map suggests that the board considered practically the entire state a problem area. Other maps and the accompanying text parceled out the particular problems among the various New Deal programs and proposed state initiatives designed to deal with them (MSPB 1935). In general, in the Ozarks, the planners envisioned national forests on most of the tax delinquent land considered submarginal for crops, but in northern Missouri, they proposed various other federal and state programs to aid farmers in establishing forest cover on slopes of more than 20 percent.

With all the planning for forestry during the New Deal, the University of Missouri established a pre-forestry curriculum in the department of horticulture in 1936 and hired Ruthford H. Westveld, a silviculturist at Michigan State University, to develop the program. They also resumed forestry extension, appointing Ralph H. Peck to the position. In addition to offering four courses in forestry, Westveld worked with Conrad H. Hammar and a land use committee at the university to compile a report on *Forest Restoration in Missouri* (1937). Coming as it did at a critical juncture for forestry in the state, the report bears review.

Westveld and Hammar introduced their report with a short history of efforts to establish

forestry in Missouri and a table on the status of forestry by state (table 2.3) that demonstrated the extent to which Missouri lagged behind virtually all other states. Only three other states—Arizona, New Mexico, and Wyoming—had no state forestry program, and they had long had the bulk of their forested acres under national forest management. Another table (p129) demonstrated that relative to its wealth and extent of forest land, Missouri's expenditures for all conservation were negligible compared with other eastern and midwestern states. Fewer than 150,000 acres of Missouri's original 31 million acres of forest had not yet been cut over, the authors claimed; half of the 31 million acres had been converted to farms, towns, or other uses, and of the remaining 15.5 million acres of cutover, 57 percent (8.9 million acres) was in farms and 43 percent (6.7 million acres) was described as wild land outside of farms, mostly in the Ozarks (p10). Owing to indiscriminate cutting, inferior species, livestock grazing, fire, and neglect, the forests produced a very small net growth of only about 25 board feet of sound commercially valuable wood per acre per year, or an estimated 312.5 million board feet for the entire state, and less than 5 percent of that growth was being put on trees of saw log size. Hence, even in the depths of the depression, sawtimber was being cut 10 times as fast as it was being grown. Westveld included an illustration comparing current estimates of cut and growth with annual "normal" wood consumption of 1,377 million board feet (presumably an estimate of consumption in a healthy rather than a depressed economy) and the estimated annual growth (2,187.5 mbf) if 75 percent of Missouri's 12.5 million acres of commercial forest were intensively managed and the rest extensively managed. Since the five states bordering Missouri on the east, north, and west produced only 237 mbf and consumed 4,219 mbf of lumber in the last good year before the depression, 1928, Westveld argued that market prospects were bright for intensive forest management in Missouri.

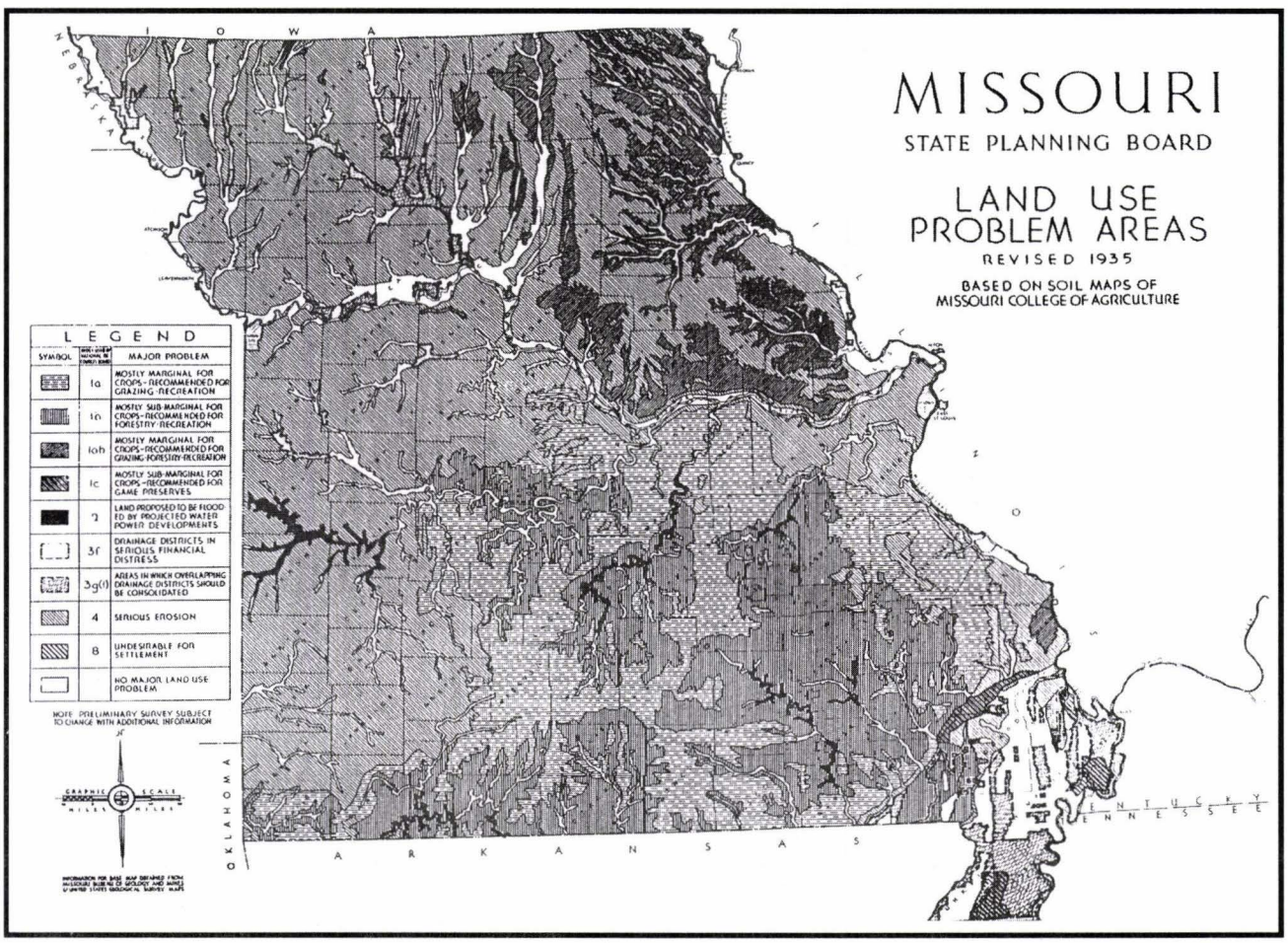

MISSOURI
STATE PLANNING BOARD
LAND USE
PROBLEM AREAS
REVISED 1935
BASED ON SOIL MAPS OF
MISSOURI COLLEGE OF AGRICULTURE
LEGEND
SYMBOL
MAJOR PROBLEM
1a MOSTLY MARGINAL FOR CROPS - RECOMMENDED FOR GRAZING - RECREATION
1n MOSTLY SUB-MARGINAL FOR CROPS - RECOMMENDED FOR FORESTRY - RECREATION
1ah MOSTLY MARGINAL FOR CROPS - RECOMMENDED FOR GRAZING - FORESTRY - RECREATION
1c MOSTLY SUB-MARGINAL FOR CROPS - RECOMMENDED FOR GAME PRESERVES
2 LAND PROPOSED TO BE FLOODED BY PROJECTED WATER POWER DEVELOPMENTS
3f DRAINAGE DISTRICTS IN SERIOUS FINANCIAL DISTRESS
3g(1) AREAS IN WHICH OVERLAPPING DRAINAGE DISTRICTS SHOULD BE CONSOLIDATED
4 SERIOUS EROSION
8 UNDESIRABLE FOR SETTLEMENT
NO MAJOR LAND USE PROBLEM
NOTE: PRELIMINARY SURVEY SUBJECT TO CHANGE WITH ADDITIONAL INFORMATION
GRAPHIC SCALE
MILES
IOWA
NEBRASKA
OKLAHOMA
ARKANSAS
TENNESSEE

Figure 2.5—*Land use problem areas, Missouri State Planning Board, 1935. Source: MSPB 1935: 2.*

Table 2.3—*Extent of forest lands in acres*[1] *and status of state forestry, 1936. Source: Hammar and Westveld 1937: Table 1.*

State	Total acreage recommended for forest management	Acreage in public ownership			Status[2] of State Forestry
		National Forests	State Forests	County and Municipal Forests	
Alabama	20,360,095	151,668	252,100	305	X
Arizona	6,585,963	6,306,000	29,000	0	--
Arkansas	24,070,533	1,515,074	1,026,793	160	XXX
California	39,895,046	19,202,647	108,613	167,900	X
Colorado	20,410,020	13,536,000	208,641	10,524	XX
Connecticut	1,184,553	0	57,196	17,989	X
Delaware	54,200	0	92	0	X
Florida	19,646,748	819,606	132,467	9,730	X
Georgia	27,614,912	396,426	1,100	20	X
Idaho	22,683,933	19,747,656	1,133,790	131,295	X
Illinois	1,931,795	39,218	4,226	---	X
Indiana	2,595,804	5,206	46,205	3,910	X
Iowa	517,621	0	0	0	XX
Kansas	---	---	---	0	XX
Kentucky	10,556,523	125,705	18,624	0	X
Louisiana	15,600,864	413,020	6,580	0	X
Maine	14,175,409	33,781	0	0	X
Maryland	1,505,870	40	0	11,971	X
Massachusetts	1,506,451	0	115,700	13,275	X
Michigan	14,873,213	1,014,237	2,098,018	4,000	X
Minnesota	15,516,001	1,508,061	1,981,708	0	XXX
Mississippi	15,874,500	668,500	545,000	297,000	X
Missouri	14,045,465	600,065[3]	0	0	--
Montana	17,518,110	13,363,082	553,228	50,340	X
Nebraska	118,655	13,330	0	0	XX
Nevada	8.973,461	4,985,848	0	0	XXX
New Hampshire	4,209,118	600,084	34,664	18,188	X
New Jersey	984,900	0	50,300	15,600	X
New Mexico	8,973,461	6,523,000	173,000	0	--
New York	14,243,238	0	2,461,674	51,214	X
North Carolina	21,863,213	575,771	18,429	98,195	X
North Dakota	500,000	480	0	0	XX
Ohio	3,395,577	0	62,010	0	X
Oklahoma	6,881,790	195,200	4,000	52,588	X
Oregon	25,051,200	13,701,834	113,132	394,915	X
Pennsylvania	13,391,306	397,710	1,647,881	447,417	X
Rhode Island	301,376	0	844	11,784	XXX
South Carolina	14,548,123	363,764	0	12,000	X
South Dakota	1,293,278	1,067,745	15,960	18,574	X
Tennessee	14,533,295	474,934	47,465	6,850	X
Texas	12,601,477	281,128	7,565	0	X
Utah	22,950,094	7,570,871	898,872	158,820	XX
Vermont	3,580,008	74,122	47,435	9,559	X
Virginia	14,487,926	701,366	588	18,500	X
Washington	18,927,825	8,140,547	1,274,349	585,511	X
West Virginia	7,652,163	688,233	21,600	0	X
Wisconsin	10,381,751	1,038,364	331,326	2,442,779	X
Wyoming	6,837,800	6,759,858	198,314	2,500	--

[1] Data from—Forest Land Resources, Requirements, Problems and Policy, Part VIII of the Supplementary Report of the Land Planning Committee to the National Resources Board, Washington, DC, 1935, supplemented by data from National Forest Areas, June 30, 1936, U.S. Dept. Agric. Misc. 0-10.

[2] X State forestry department has fire protection organization and produces nursery stock for distribution to farmers.
XX Either a state forestry department or other facilities for producing nursery stock only.
XXX State forestry department has fire protection organization and in most cases does educational work.

[3] Increased to 1,000,000 June 1, 1937.

To Westveld's estimates (table 2.4), the author has added estimates as of 1989 in cubic feet, the current measure for wood products (Spencer *et al.* 1992). In that year Missouri produced about 135 million cubic feet of timber products while its forests grew at about 267 mcf, but its citizens consumed about 423 mcf (Howard 1999), indicating that while forest conditions in 1989 were far better than in the 1930s, Missourians still consumed more wood than they produced. And their forests still were not growing at anywhere near the rate of potential growth estimated in 1937 or the even greater rate projected in 1989.

Table 2.4—*Comparison of Missouri's lumber production and estimated timber growth, normal wood consumption, and estimated growth under forestry practice, 1937 and 1989. Categories and figures in million board feet for 1937 from Hammar and Westveld (1937): fig. 5; cut and growth figures in million cubic feet for 1989 from Spencer* et al. *1992; consumption figures in mcf from Howard 1999; figures in mbf for 1989 derived by applying conversion factor of 5.75 (Shifley, pers. comm.).*

	1937 (mbf)	1989 (mcf)	1989 (mbf)
Present annual cut of lumber	100 mbf	136 mcf	782 mbf
Present annual growth on all trees	312.5 mbf	267 mcf (ave. 1972-89)	1,535 mbf
Annual normal wood consumption (all products)	1,377 mbf	423 mcf (83 mcf/capita x 5.1 m people)	2,432 mbf
Estimated annual growth under forestry practice	2,187.5 mbf	651 mcf (potential growth discounted 10%)	3,743 mbf

The status and prospects for wildlife populations were addressed in the forest report by Rudolf Bennitt and Werner Nagel of the zoology department at the University of Missouri, who had just completed a more extensive *Survey of Resident Game and Furbearers* (1937) modeled on Aldo Leopold's earlier survey. They reported that of woodland species, ruffed grouse, beaver, and otter were rare or vanishing; wild turkey, deer, raccoon, mink, weasel, and gray fox were present in small numbers and generally decreasing; and only opossum, skunk, squirrels, and red fox were abundant and maintaining their numbers. Bennit and Nagel included a table (table 2.5) comparing estimated populations of five species as of 1935 with populations 100 years earlier and the restoration possible in Missouri under proper management.

To this table the author has added a column of estimated populations as of 2000, revealing that Bennitt and Nagel underestimated by an order of magnitude the prospects for wildlife restoration in Missouri for most species. The difference in the projected and actual populations of deer, wild turkey, raccoon, and otter is a measure of the remarkable success of the wildlife management program, at least for these particular game species, while the shortfall of current annual timber growth compared with Westveld's projections under forestry practice is a measure of the distance yet to travel in forest management. From another perspective, however, it is conceivable that the remarkable growth in wildlife populations in Missouri stems in part from the relative lack of intensity in forest management on the bulk of woodland held in private hands.

The 1937 report on forest restoration went into considerable detail on the economic plight of forested regions of the state and prospects for mitigating it. The problems of fire and grazing were particularly intractable; much of the Ozarks was still open to free-ranging livestock (fig. 2.6) and Ozarkers typically burned the woods to encourage forage, but the forests were now too degraded to support the cost of fencing. Tax delinquency was endemic in the state, with rates in most Ozark counties ranging from 30 to 60 percent of the land, and the sale of land for back taxes typically did not bring in enough to pay the costs of the sale. As a result, Ozark counties were unable to provide the most basic services, including education. The only solution appeared to be massive public ownership of forest land and an aggressive program of fire control and reforestation. The authors of the report accepted the 1935 projections of the state and national planning boards for 8 million acres of public forests in Missouri—about 7 million federal and 1 million state—though they focused most of their attention on the need for an active state forestry agency to coordinate fire control and the myriad federal programs for reforestation of farm forests and other private lands.

Table 2.5—Potential and estimated game production in Missouri, 1835, 1935, and 2000. From Bennitt and Nagel, "Game and fish habitats," in Hammar and Westveld (1937) with estimated populations as of 2000 from Missouri Department of Conservation (Bill Heatherly, pers. comm., Sept. 2001).

POTENTIAL GAME PRODUCTION IN MISSOURI (Bennitt & Nagel, 1937)				
Species	**Estimated population 100 years ago (c. 1835)**	**Spring breeding population 1935**	**Conservative estimate of possible restoration under management**	**Estimated population spring 2000 (MDC)**
Deer	700,000	1,800	85,000	850,000-1,000,000
Wild turkey	250,000	2,500	50,000	575,000
Ruffed grouse	400,000	100	98,000	5,000-10,000
Raccoon	?	19,000	133,000	1,000,000-2,000,000
Otter	1,700	70	1,100	11,000-18,000

STATE FORESTRY IN MISSOURI

By the time the bulletin on *Forest Restoration in Missouri* appeared, Missourians had finally voted to establish a more aggressive state conservation agency headed by a new "non-political" commission. The Izaak Walton League, Fish and Game League, and chambers of commerce had been promoting bills to take conservation out of politics ever since the early 1920s—often at cross purposes, as we have seen, with the Missouri Forestry Association's efforts to establish an independent state board of forestry. After yet another unsuccessful effort in 1935 to secure legislative action, a group of well-placed sportsmen and civic leaders founded a new organization, the Restoration and Conservation Federation of Missouri, and embarked on a new strategy. Their aim this time would not be a bill in the legislature, which had so utterly failed in the past, nor even a statute placed on a statewide ballot by initiative petition, which would risk amendment by a subsequent legislature, but a carefully drawn constitutional amendment that would create a bipartisan commission with full authority for all phases of a broad conservation program. The campaigns for petition signatures and then for the vote, led by Columbia publisher, civic leader, and sportsman E. Sydney Stephens, were models of effective organization; they resulted in an overwhelming victory, carrying more than 70 percent of the Missouri vote in the presidential election of 1936. But, though the new Missouri Conservation Commission would have authority for forestry as well as fish and wildlife, most of the 29 counties in which it failed to pass were forested counties in the Ozarks, where most residents still deeply distrusted government (Callison 1953).

Significantly, the constitutional amendment as drafted did not give the new commission authority over parks, even though Missouri's 70,000 acres of state parks contained the only forested lands owned by the state. We have inadequate documentation of the thinking of Stephens and other conservation leaders of the time on this issue, but the omission of parks was surely deliberate, an effort to end the diversion of 25 percent of hunting and fishing license receipts to the state park fund, which had long been resented by sportsmen (but ironically, license receipts would continue to be a major support for the new forestry program). The leaders may have believed that the new commission would in effect control most of the parklands anyway, since much of the acreage was used for game refuges and fish production or had been improved by CCC forestry camps. Whether state lands would be managed as parks or forests was in effect left to be resolved by a new state park board, established by an emergency act of the general assembly in its 1937 session, and the new conservation commission, appointed effective July 1, 1937 (Flader 1992).

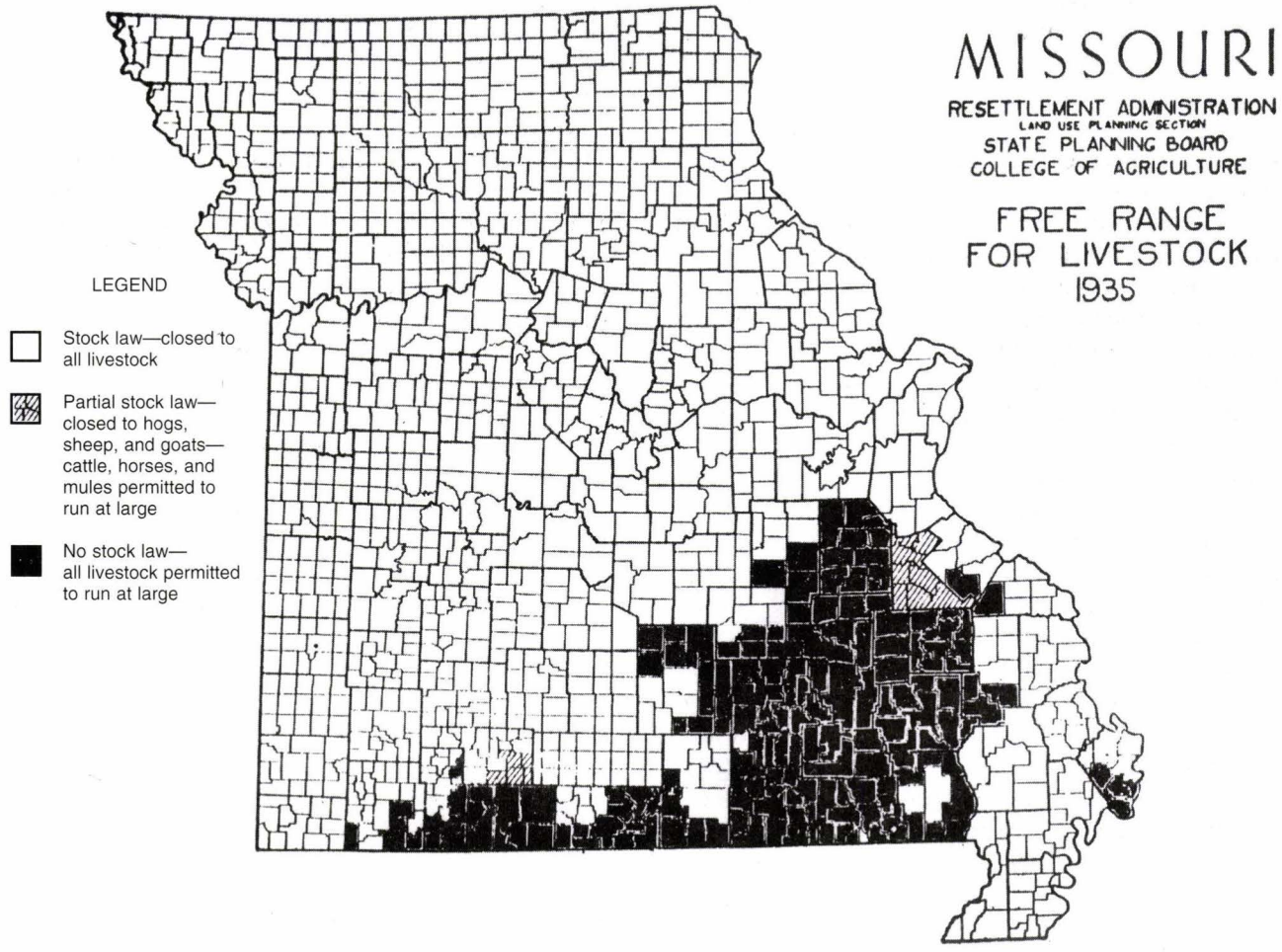

MISSOURI
RESETTLEMENT ADMINISTRATION
LAND USE PLANNING SECTION
STATE PLANNING BOARD
COLLEGE OF AGRICULTURE
FREE RANGE
FOR LIVESTOCK
1935
LEGEND
Stock law—closed to all livestock
Partial stock law—closed to hogs, sheep, and goats—cattle, horses, and mules permitted to run at large
No stock law—all livestock permitted to run at large

Figure 2.6—*Free range for livestock, 1935. Source: Hammar and Westveld 1937: fig. 11.*

As it happened, the responsibilities of the conservation commission and state park board with respect to state-owned lands would not be formally separated until 1942, but a series of inspired appointments and a determination to keep federal funds flowing to state lands made for a relatively smooth course through what could have been dangerous shoals. To the new conservation commission Governor Lloyd Stark appointed E. Sydney Stephens, who was elected chair; John F. Case, editor of the *Missouri Ruralist*; A.P. Greensfelder, a park-minded member of the Missouri State Planning Board; and outgoing game and fish commissioner Wilbur Buford, who had been responsible for coordinating the flow of federal conservation funds to state lands and projects. The commission conducted a national search for a director of conservation, selecting I.T. Bode of the U.S. Biological Survey. Under terms of the emergency park act, he would also serve with the Governor and the attorney general on the three-man state park board and as director of state parks. Another inspired appointment, Bode was by professional training a forester with long experience in extension forestry and recent involvement in organizing cooperative wildlife research programs. Like former state forester Frederick Dunlap and wildlife ecologist Aldo Leopold, who almost certainly recommended Bode, Bode believed in taking conservation programs directly to landowners and the general public, educating them in an effort to change their attitudes and behavior toward forests and wildlife. He believed his department's efforts needed to be focused primarily on farms and other private lands rather than on state-owned lands. His relative lack of acquisitiveness for public land resulted in remarkably small additions to state holdings during his tenure, especially in comparison with the million or more acres envisioned by the state planning board, and undoubtedly made relations with

the state park board more amicable than they might otherwise have been.

The conservation department's new forestry program was headed by George O. White, who had been involved in administering the new national forests in Missouri. White hired five more professional foresters and assigned them to head fire protection districts in the Ozarks, to educate landowners and work with CCC camps and local volunteers to control fires on both private and public lands. In 1940, the commission established a farm forestry program in north Missouri in cooperation with the Soil Conservation Service, and under the 1942 Norris-Doxey Act, the U.S. Forest Service and the state began cooperating on a farm forestry program in the Ozarks. Both programs were devoted primarily to educating woodland owners, encouraging them to plant trees and in the process become advocates for fire control. To provide seedlings for reforestation, in 1940 the department began a nursery at Meramec State Park and then in 1947 took over an idle Forest Service nursery at Licking, where they filled annual orders for millions of seedlings through the university's county extension agents (Keefe 1987: 198-214, 343).

From the start of the new forestry program, the foresters apparently also managed certain state park lands, including about 34,000 acres of parks that had had little recreational development and were used primarily as game refuges. The department had little money to purchase new state forests, the forestry program being supported by an allocation of 15 percent of department income from hunting and fishing permits, much as state parks had earlier been supported. In 1941, following the contentious election of Republican Governor Forrest C. Donnell, the park board agreed to surrender to the conservation commission jurisdiction over some 22,000 acres in two large forested parks, Deer Run and Indian Trail, and two fish hatcheries, Sequiota and Chesapeake, and the two departments and their staffs were for the first time physically separated (SPA-SPB Min. 1941). But considerable confusion and contention persisted between the two agencies. In fact, the conservation commission would continue to oversee fish, wildlife, and forest-related management efforts in the parks, and the foresters would continue to manage portions of Meramec and Sam A. Baker State Parks as if they were commission lands until an agreement was finally reached in 1980 giving the commission the portion of Meramec east of the river and retaining Baker in exclusive park status (Flader 1992). The commission acquired a few new areas of its own, including Rockwoods and DuPont reservations and some land for Cardareva State Forest, but a 1943 cooperative report on *Missouri Forests* by the Forest Service and the commission, which still assumed that 8 million acres of forest in Missouri—more than half the forest land and nearly one-fifth the land area of the state—would ultimately be publicly owned, listed only 61,000 acres of state-owned forest land, including 16,000 acres in state parks (USDA 1943).

Asking "Whither Missouri?," Aldo Leopold assessed the prospects for conservation under the new regime when he was invited to speak at the dedication of the Ashland Wildlife Area in Boone County in 1938. He began by praising the state not only for passage of a good law but especially for the quality of its professional conservation leadership and the excellent start it had made on research. But then he asked, "Who is going to practice conservation on the land?" The easy assumption was government, state and federal. But Leopold thought it highly unlikely that public land, even in the remote future, would ever exceed one-fifth of Missouri (in 1938, it was about 3 percent; in 2000, 7 percent). The challenge, therefore, was for private owners to practice conservation on their own land. As a test of current practice, Leopold had tallied 100 farms along his drive from the Iowa line to Columbia. Of these, only 40 had any woodlot; and of these 40 woodlots "39 were grazed and thus doomed to ultimate extinction." Other measures of conservation such as wildlife cover and soil erosion were no better; there was as yet "very little visible conservation practice on Missouri farms." When our wild crops have become "an expression of pride in land," Leopold concluded, "then and not until then will we have conservation in Missouri."

After the United States entered World War II in 1941, conservation programs stagnated in funding and manpower at the same time as they were called on to encourage more production for the war effort. A Timber Production War Project, begun in 1943, helped push Missouri lumber production higher than in any North Central or Great Lakes State; among Missouri products was walnut for gun stocks. The association with increased production

gave a certain credibility to professional forestry. Perhaps the exigencies of wartime also emboldened foresters to reassert the need for public regulation of forest practices on private lands, as they did in a 1943 federal-state cooperative bulletin on *Missouri Forests*:

> Is it not time for the people of Missouri to assert their interest in the management of all forest lands so that remaining supplies can be conserved and future supplies insured? In return for this owner cooperation in conservation—public control, if we must give it a name—the public must assume certain responsibilities, such as fire protection, equitable taxation, cooperative marketing etc., just as in the case of the urban dweller (p24).

POST-WAR INSTITUTIONALIZATION

Following the war, as attention shifted back to private enterprise in reforestation and timber production, a coalition of timber operators, state and federal forestry officials, Ozark legislators, and the Conservation Federation promoted legislation to encourage forestry practice on private lands (Hall 1946), relying primarily on incentives rather than regulation. The Missouri General Assembly finally passed its first significant forestry legislation, the State Forestry Act of 1946, which established a "forest cropland" program and penalties for woods arson; and for the first time it appropriated funds—$150,000 from the state's general revenue—for forestry purposes, mostly fire control, which enabled the state to receive more matching funds from the federal government. The forest crop program allowed private landowners to defer part of the annual taxes on land entered under the program for 25 years in exchange for following management guidelines and paying a yield tax when the timber was harvested. By 1950, over 140,000 acres of private land were entered under the program along with 150,000 acres of state forests; and the forestry division budget, now more than $650,000 a year (in a total commission budget of about $3 million), was comprised of approximately equal funding from general revenue, hunting and fishing license receipts, and federal allotments under the Clarke-McNary and Norris-Doxey Acts. Some 6 million acres were under forest protection districts, only about 2 percent of which burned annually, compared with an estimated 1 of every 3 acres before fire control, and Missouri was on its way to a more effective state forestry program (OM 1951-52). (By 2000, forest acreage burned annually would be only about one-tenth of 1 percent, but the forest cropland program, rendered ineffective by the high price for land, would be moribund.)

In 1947, the University of Missouri did its part to institutionalize forestry in the state by establishing a new department of forestry to offer a 4-year bachelor's degree. R.H. Westveld, who had resigned in 1938 to accept a professorship at the University of Florida, was brought back to head the department, and the new program with eight faculty won accreditation in 1950. That same year the department was authorized to offer a master's degree and then, after becoming a school of forestry in 1957, began in 1962 to offer a doctorate. The forestry faculty developed a summer camp at the University Forest, 7,300 acres in Butler County blocked up from remnant lands of the original Morrill grant, and conducted research at several other university-owned tracts around the state. A branch office of the Central States Forest Experiment Station of the Forest Service was located in Columbia in 1948, and the forestry faculty also negotiated cooperative agreements for research with the conservation commission and, later, the state park board. But the forestry extension program continued as essentially a one-man operation (Westveld 1970).

Just as the new program at the university was getting underway, the Forest Service completed the first intensive survey ever made of Missouri's forest resources. Authorized under the McSweeney-McNary Act of 1928, which greatly expanded research capability by providing for regional forest experiment stations and a periodic nationwide inventory of timber resources, the survey was based on a scientifically designed sampling procedure involving both aerial photographs and ground plots that could provide comparable statistics to track change over time. In Missouri, the inventories would be conducted in 1947 (King *et al.* 1949), 1959 (Gansner 1965), 1972 (Spencer and Essex 1976), and 1989 (Hahn and Spencer 1991), with cooperation over the years from the state forestry division and the university. In 1999, the survey would change to a continuous annual inventory system, measuring one-fifth of the plots each year on a rotating basis, with the first cycle to be completed in

2004 (Schmidt 2001). The first survey showed clearly the impoverished condition of Missouri's forests, with only about one-fifth the stocking of sawtimber that could be supported under good management and a high proportion of "cull" and defective trees impeding improvement in productivity, especially in the heavily exploited Ozark region. Exacerbating the problem was an abnormally high cutting drain on sawtimber in 1946, higher than at any time in the previous three decades, undoubtedly to feed the post-war housing boom and the pent-up demand for other products. At current rates, the report indicated, it would require 225 years to reach the desired volume of sawtimber in the state's forests.

By the second inventory in 1959 (Gansner 1965), the outlook was somewhat improved; though sawtimber was smaller and younger than in 1947, it was growing at a more rapid rate. But the dwindling supply of merchantable sawtimber (15 inches diameter at breast height) posed a threat to the state's traditional forest-based industries. The annual harvest in 1958 was only half that in 1946, and the number of sawmills had declined from 2,600 to only about 1,000 between inventories. Ninety percent of the timber-producing land was privately owned, sixty percent of it by farmers, yet the volume increase of sawtimber on private land was less than one-tenth that of the increase on better managed public lands.

Missourians, however, no longer regarded public ownership as a panacea, if indeed they ever had. A July 1958 report by the forestry committee of the Conservation Federation of Missouri, chaired by John Powell, noted that the philosophy regarding public ownership of forest land had changed dramatically from that of the 1930s in the altered economic conditions following World War II, and recommended no increase in national or state forests in Missouri except to consolidate existing holdings or for special purposes such as watershed protection or wildlife management. The future of Missouri's forests and forest industries rested in the hands of more than 200,000 private landowners—almost 90 percent of them with fewer than 100 acres—and very few private owners were practicing forestry. The Conservation Federation report was timed to coincide with a major Missouri Forest Resource Conference the following October, for which planning had begun nearly a year earlier under the lead of Leo A. Drey, chairman of the Missouri Forest Industries Committee and the state's largest private forest land owner. Conceived initially as a rally against forest fire, the conference was broadened to include all resources, including industrial and recreational potential, with particular emphasis on private land—doing the right things, as Drey put it, "to convert lazy acres into busy acres" (LAD f8-11).

The situation with private landowners would get worse before it would get better. According to a study of small landowners in Wayne County (Farrell 1964), only 11 percent of landowners had ever even consulted a forester for advice. By the third forest survey in 1972, a change in land use alarming to foresters was underway, with more than 1.7 million acres of commercial forest area having been converted to pasture, cropland, and other uses since the 1959 survey (Jakes *et al.* 1979). The problem was particularly acute on some of the better quality forest sites in northern and southwestern Missouri and in the southeastern lowlands. And farmers were still being exhorted by Secretary of Agriculture Earl Butts to "plant fence-row to fence-row" in order to produce soybeans and other commodities for international trade. Meanwhile, rural land prices were rising rapidly, fueled by high prices for crops and cattle, pricing many forest lands beyond the range of the state forest law's $10/acre limit for forest cropland. For farms on poorer soils in the Ozarks, livestock production—mainly cattle and hogs—had long contributed more to yearly farm sales (about 85 percent) than forest products (only about 3 percent), offering little incentive for farmers to invest in forest management (Ehrenreich and Ralston 1963). When the Missouri General Assembly in 1967 finally abrogated the Open Range Act of 1808 (Calvert 1967) to end the traditional practice of free-ranging livestock in recalcitrant counties in the Ozarks, the impetus came largely from conservationists and public land managers. Farmers throughout the state continued to use their own woodlands for livestock.

One private landholding that would prove a conspicuous exception to the generally poor record for private forest management was Pioneer Forest, owned by St. Louis businessman Leo Drey, which grew rapidly from its origins in 1951 to become the state's largest private holding when Drey purchased 90,000 acres being liquidated by National Distillers in Shannon and nearby counties in 1954

(Jackson 1988). The status and prospects for Ozark forests in the 1950s were indicated by the price Drey paid for his first 125,000 acres—little more than $4 per acre. But the Distillers land had been managed by a forester who had initiated a series of permanent research plots, one-fifth acre in size, one for every 640 acres of the forest, to conduct a continuous forest inventory to measure change and growth over the years. Drey had a vision—to restore a profitable forest by conservative single-tree selection uneven-aged management that would be productive also of wildlife, recreation, and other social and scientific values—so he resolved to continue the inventory every 5 years and extend it to his total holdings, eventually 160,000 acres. It was an inventory system that would be more reliable and potentially more revealing than that of the Forest Service, in that it sampled more acres and would offer comparable measurements of the same trees in the same plots for generations.

Drey's gigantic experiment in uneven-aged management and continuous inventory was destined to become even more significant as foresters on public lands—both federal and state, in the Ozarks as elsewhere in the country—turned increasingly to even-age management by clearcutting in the post-war years. In an environment in which demonstrations of management by public agencies were geared almost entirely to even-aged techniques, it would become Drey's mission to demonstrate that ecologically sensitive uneven-aged management was a viable alternative for both private and public landowners in the oak-hickory forests of the Ozarks.

RISE OF ECOLOGICAL CONSCIOUSNESS

As it happened, the 1960s were a period nationwide when a dramatic post-war increase in recreational demands on public lands fueled by automobiles, better highways, and more leisure time began to coincide with public discovery of ecology and insistence on higher standards of environmental management. The decade was ushered in with the Multiple Use-Sustained Yield Act of 1960, which mandated equal consideration for recreation and wildlife with the more traditional emphasis on timber and range resources on the national forests. Ecological issues became matters of public discussion with the publication in 1963 of Rachel Carson's explosive bestseller *Silent Spring* and the success in 1964 of the massive public campaign for the National Wilderness Preservation Act. A multi-volume report of the Outdoor Recreation Resources Review Commission spurred Congress in 1964 to establish the Land and Water Conservation Fund, a 50-50 matching program of federal grants through which Missouri alone would receive more than $60 million for state and local parks by about 1980 (after which federal funds would shrivel), but still public lands were hard-pressed to keep up with burgeoning recreational demands.

Probably without intending, Missouri became a leader in an environmental effort characteristic of the decade of the sixties, the preservation of natural streams, when the Ozark National Scenic Riverways, established in 1964, became the nation's first federally protected river and the prototype for the National Wild and Scenic Rivers Act of 1968 (Stevens 1991). For a few years in the early sixties, there was relative unanimity in the state about the desirability of preventing dams on the Current and Jack's Fork Rivers through some sort of national designation, with disagreement principally over which agency, the Forest Service or the National Park Service, should have the responsibility (Sarvis 1998). Leo Drey, whose Pioneer Forest abutted 35 miles of the two streams, favored the Forest Service with its prospect for more dispersed, lower density recreation, but he lost. In the aftermath to a shaky start for Park Service administration, many Ozarkers reverted with new determination to their traditional anti-government stance. When Missouri conservationists in the late 1960s sought to win establishment of a state system of scenic rivers similar to those being created in most other eastern states following the earlier Missouri and national models, angry rural landowners organized in opposition. After repeated threats and some actual acts of violence, supporters aborted the measure in 1970. Missouri would become just as conspicuous among the states by its unwillingness for the remainder of the century to develop further institutional measures to protect its wealth of natural streams as it had been earlier in the century to do the same for its forests.

In another environmental arena, however, Missouri was already a recognized leader among the states and would become more so as a result of strategic action taken at the high tide of public environmental consciousness around 1970. This was its pace-setting

conservation commission. The commission had been blessed since its establishment in 1937 by a strong, professional staff supported by high-quality gubernatorial appointments to its policymaking board and a dedicated and vigilant citizen support group, the Conservation Federation. When the commission's third director, Carl Noren, took over in 1967, he was conscious of a need to reassess the department's programs in light of heightened public interest in the environment and decided limitations in the traditional source of funding through hunting and fishing permits.

With funding from the Edward K. Love Foundation of St. Louis, Noren recruited three nationally prominent conservationists to make an independent evaluation of the commission's programs. All three members of the blue-ribbon committee had ties to Missouri: the chairman, A. Starker Leopold (son of Aldo) of the University of California-Berkeley, had done the research on wild turkeys in Missouri that led to their remarkable restoration; Charles Callison, executive vice president of the National Audubon Society, had been editor of the *Missouri Conservationist* and then executive secretary of the Conservation Federation before shifting to the national arena in 1951; and Irving Fox, head of the Water Resources Center at the University of Wisconsin, had worked with Noren on the Arkansas-White-Red River Basins Survey out of which the concept of national protection for the Current River had emerged. The committee's report (Leopold *et al.* 1970) issued a dramatic challenge to the commission to redefine its goals and reorient its programs in line with the new ecological thinking sweeping the nation. The department issued an immediate response (MDC 1970) accepting the challenge to reorient its programs of land management, research, and education, setting a goal to double its 300,000 acres of wildlife and forest lands within 20 years, and estimating that the goal could be met with an additional $21 million per year (at a time when its annual budget was about $10 million).

An analysis of the Leopold report and comments of department staff during its preparation leaves little doubt that the greatest arena of contention in the process was the management of forest lands. One of the committee's four suggested goals was "to foster realization of maximum social values from the forests and wildlands of the state," but the committee admitted to having a "major reservation" about the objectives of the forestry program:

> By and large, the ongoing program seems weighted toward producing commercial timber on land where wildlife and recreational values might outweigh timber values. Programs of fire control, farm forestry, the Forest Crop Land Program, forest products programs, pest control program, and raising of nursery stock are all "sawdust" oriented (p22).

In calling for a reorientation of forest management, the committee challenged the conservation commission to consider how forest management would be altered and timber production affected if recreation, wildlife, and other social values, including ecosystem preservation, were to be the primary objectives, and whether the gains would be worth any loss in timber output that might result. The forestry section of the draft report met with by far the greatest criticism from certain department staff, with various individuals bridling at being characterized as "sawdust oriented"—as one person noted, "We are probably 'sawdust oriented' but we are not sawdust dominated"—and calling the comments "unfair" and "unusually hard" on the forestry program; staff members thought the committee did not appreciate forestry's economic contribution to the state or the extent to which it was already benefiting wildlife and watershed protection (CP b10). But in the published report, the language regarding forest management remained much as in the draft.

In retrospect, it is clear that the challenge to foresters in Missouri and their defensive response were part of a larger phenomenon. Foresters with their commitment to efficient sustained-yield production of resources had led the conservation movement in the Progressive Era and they were still clearly dominant among the natural resource professions. But after shifting in the post-war era to heavy reliance on clearcutting as a harvest technique virtually nationwide, especially on the national forests—on the Mark Twain and other eastern forests the shift began around 1964—they became the target of increased public criticism by environmentalists, including a few individuals from within the profession (U.S. Congress 1970), for their overemphasis on timber at a time of increased public interest in recreation,

wildlife and other forest values. In Missouri, professional foresters had led the conservation department since its inception until the appointment of wildlife biologist Noren in 1967, and forestry's share of the budget was considerably greater than that of fisheries, game, or field operations—this despite the fact that anywhere from 30 to 50 percent of the forestry budget, depending on how it was calculated (CP b10), came from hunting and fishing permit revenue. It is hardly surprising that foresters fought to maintain their professional standing and prerogatives—or that, in the new era of ecological consciousness, they were challenged by citizen environmentalists and professionals from other less powerful fields.

Following submission of the Leopold report, a citizens committee formed to follow the lead of their predecessors in 1936 by undertaking an initiative petition campaign for a program, now called "Design for Conservation" (MDC 1971), that would fund major land acquisition and broadening of the state's conservation programs by a tax on soft drinks expected to produce about $21 million a year. The logic, as argued half a century earlier by Aldo Leopold and reaffirmed by his son's blue-ribbon committee, was that the shift of emphasis to programs benefiting the general public rather than primarily hunters and fishermen would require new sources of funding from the general public. In the "Design," for example, the forestry program was slated to receive slightly over 10 percent of the new funds principally to acquire new state forests in northern and western Missouri near urban areas and to further develop its programs in urban and community forestry. Rural land values were rapidly escalating at the time, so there was no danger that Missouri, even with the new program, would begin to approach the amount of state-owned land in comparable states such as Pennsylvania, Michigan, Wisconsin, or Minnesota. When the initiative petition with 164,000 laboriously gathered signatures was ruled invalid on a technicality, stunned and dispirited conservationists waited until 1975 to try again, this time opting for a one-eighth of 1 percent sales tax (Keefe 1987, 118f). The program (MDC 1975) finally won approval by the voters in 1976, ushering in an era of land acquisition and development, research, education, and public outreach that would make the Missouri Conservation Department even more the envy of the nation (fig. 2.7).

The conservation department was not the only environmental program in Missouri to be revitalized in the 1970s. When the switch to even-aged management and the conversion of hardwoods to pine by clearcutting and aerial spraying of herbicides on the Mark Twain National Forest in the late 1960s raised concerns about wildlife habitat, wildlife and forestry specialists in the conservation department and on the national forest began cooperating on the development of habitat guides and modification of timber management for wildlife on federal and state forest lands (Evans 1974). It became known as the Missouri Plan, a model for federal-state cooperative management nationwide (Creighton 1981), though environmentalists would point out that it still relied essentially on even-aged techniques and favored game species like deer and turkeys that thrived on "edge." The University of Missouri (MU) School of Forestry in 1973 merged with the fisheries and wildlife programs from the biology division in the College of Arts and Science, the Cooperative Wildlife Research Unit, and the Cooperative Fishery Research Unit to form the School of Forestry, Fisheries, and Wildlife, laying the groundwork for future cooperative efforts.

And at the state level, a major new agency, the Missouri Department of Natural Resources, entered the arena. The original proposal of a "Little Hoover Commission" on reorganization of state government in 1971 would have combined all environmental functions, including air and water quality, land reclamation, state parks, and fish, wildlife, and forestry, into a single department of natural resources headed by a secretary appointed by the Governor, on the model of superagencies previously established in other states. After fierce opposition by the conservation commission, which feared loss of autonomy in the new agency, legislators ultimately decided both to retain the conservation department with its commission and to create a new department of natural resources for the remaining functions. State parks, which had been cast out in 1937 but which the commission now wished to recapture, were included instead in the new DNR in 1974 (Flader 1991).

The new DNR was led by bright young ecologically minded professionals who were quite willing to disagree with the seasoned leadership of the conservation department on certain time-honored management policies,

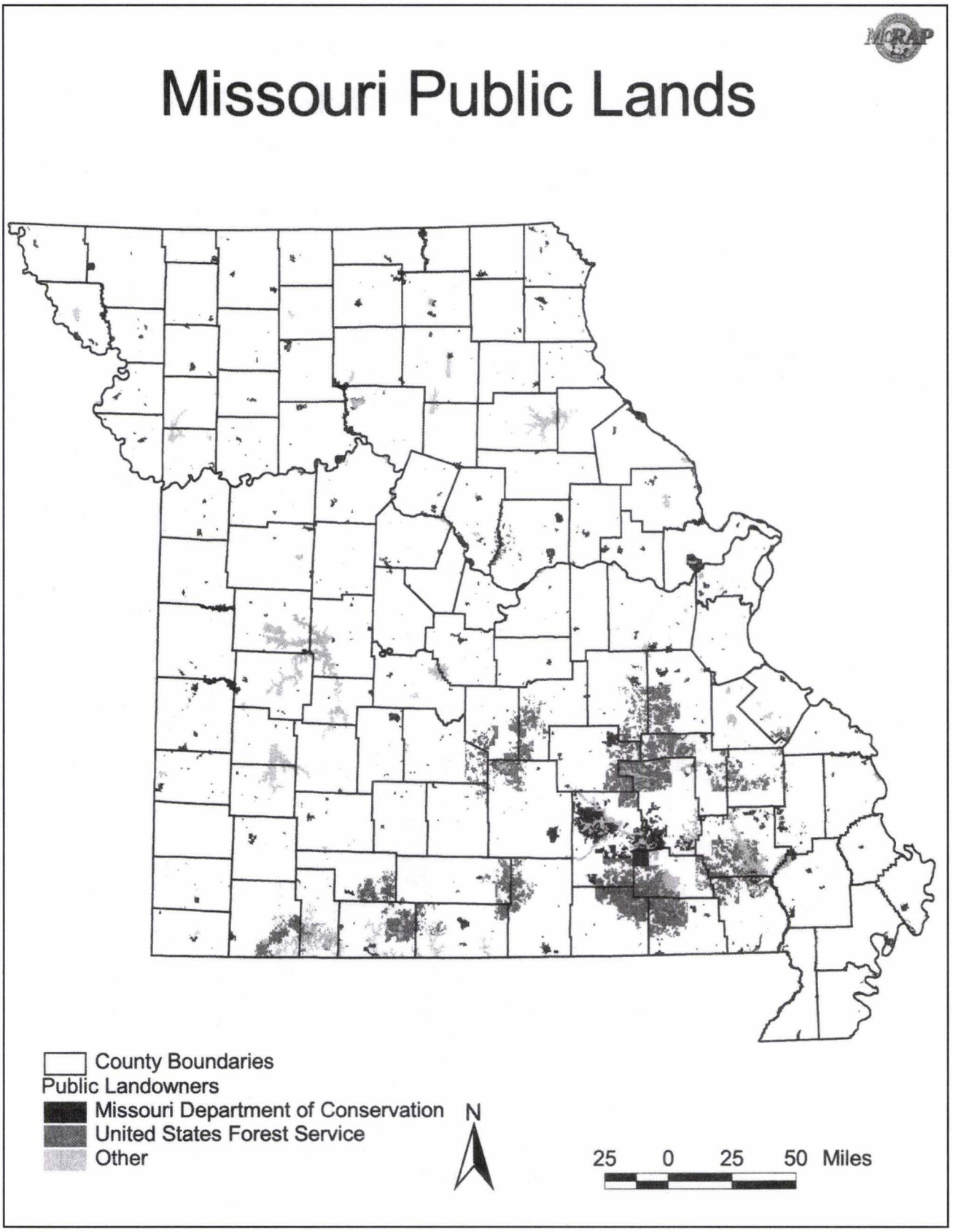


Figure 2.7—*Missouri public lands, 2000. Source: MORAP.*

such as wildlife food plots or timber stand improvement in parks, but they were ready also to cooperate in other areas. The two agencies, along with the Forest Service and the National Park Service, cooperated most notably beginning in 1977 on a statewide natural areas system that would grow to more than 170 areas containing over 54,000 acres (fig. 2.8; Kramer *et al.* 1996; MDC 2000), and they agreed upon a statewide classification of natural divisions and sections of Missouri (Thom and Wilson 1980) that became the basis for planning for numerous agency programs. The heightened interest in the state's natural ecosystems led to creative programs of ecological restoration, especially in state parks, natural areas, and certain wildlife lands. When concerted citizen action led in 1984 to enactment of another conservation sales tax, this time one-tenth of 1 percent split equally between soil conservation and state parks, years of wrangling between conservation and DNR over control of parks came to an end and the state park system entered upon a renaissance similar to that of the conservation department (Flader 1992). Missouri henceforth would have two nationally recognized programs, conservation and parks.

In addition to their efforts on behalf of better funding for conservation, parks, and soils at the state level, Missouri citizen groups also fought doggedly for years to enhance recreational resources, including wilderness, and to infuse greater environmental sensitivity into management of the Mark Twain National Forest. Though managers of the Mark Twain answered to more remote powers in Washington, in some ways citizens enjoyed greater leverage with the Forest Service than they did with state agencies. This was because of provisions of the Wilderness Act of 1964, which established a procedure for congressional designation of roadless wilderness areas on federal lands; the National Environmental Policy Act of 1969, which mandated environmental impact assessment of new federal programs with opportunity for citizen input; and the National Forest Management Act of 1976, which required comprehensive planning for all national forests with broad citizen participation. By contrast, in their efforts to insulate conservation from politics by the constitutional amendment establishing the conservation commission back in 1936, Missourians had laid the foundation for a professional agency that remained effectively insulated also from citizen leverage, much as the early Forest Service itself had been before the new federal laws.

The Missouri Wilderness Coalition, spearheaded by Columbia activist John Karel and others, formed in the early 1970s to promote establishment of wilderness areas on the Mark Twain (MWC; Karel 1978; Farmer 1999). When their initial efforts to include four Missouri areas in the Eastern Wilderness Act of 1975 failed owing to last-minute opposition from rural landowner organizations upset by the inclusion of private lands within proposed wilderness boundaries, the group redoubled their efforts to identify and promote more appropriate areas. The coalition won congressional designation of eight areas totaling 71,358 acres (including 8,000 acres of cypress-tupelo swamp in Mingo National Wildlife Refuge) in a series of bills passed in 1976, 1980, 1982, and 1984 against considerable resistance from professional foresters and outright opposition from timber and mining interests. The coalition also gained designation of seven additional "sensitive areas" originally promoted for wilderness in the management plan for the Mark Twain, finally released in 1986 (USDA-FS 1986), in which the Forest Service planned to manage for non-motorized recreation and to perpetuate near-natural conditions using uneven-aged management "emphasizing a large tree environment." In the midst of the long struggle over wilderness, the Missouri Department of Natural Resources in 1978 established a state wild area system modeled on the federal wilderness system, which would grow in the next 2 decades to some 23,000 acres in 11 areas, all in state parks. The wilderness coalition and other organizations repeatedly asked the conservation department to participate in this system, as they did in the successful interagency collaboration on natural areas, but to no avail (Pryor 1988).

CONTESTED MANAGEMENT

Controversies over forest management on public lands intensified after 1985, when Missouri's newly elected Governor John Ashcroft appointed his campaign manager and former state Republican chairman, Rolla lumberman John Powell, to the conservation commission. Powell, whose own 18,000-acre tree farm was a model of superb even-aged management, had long been a fierce opponent

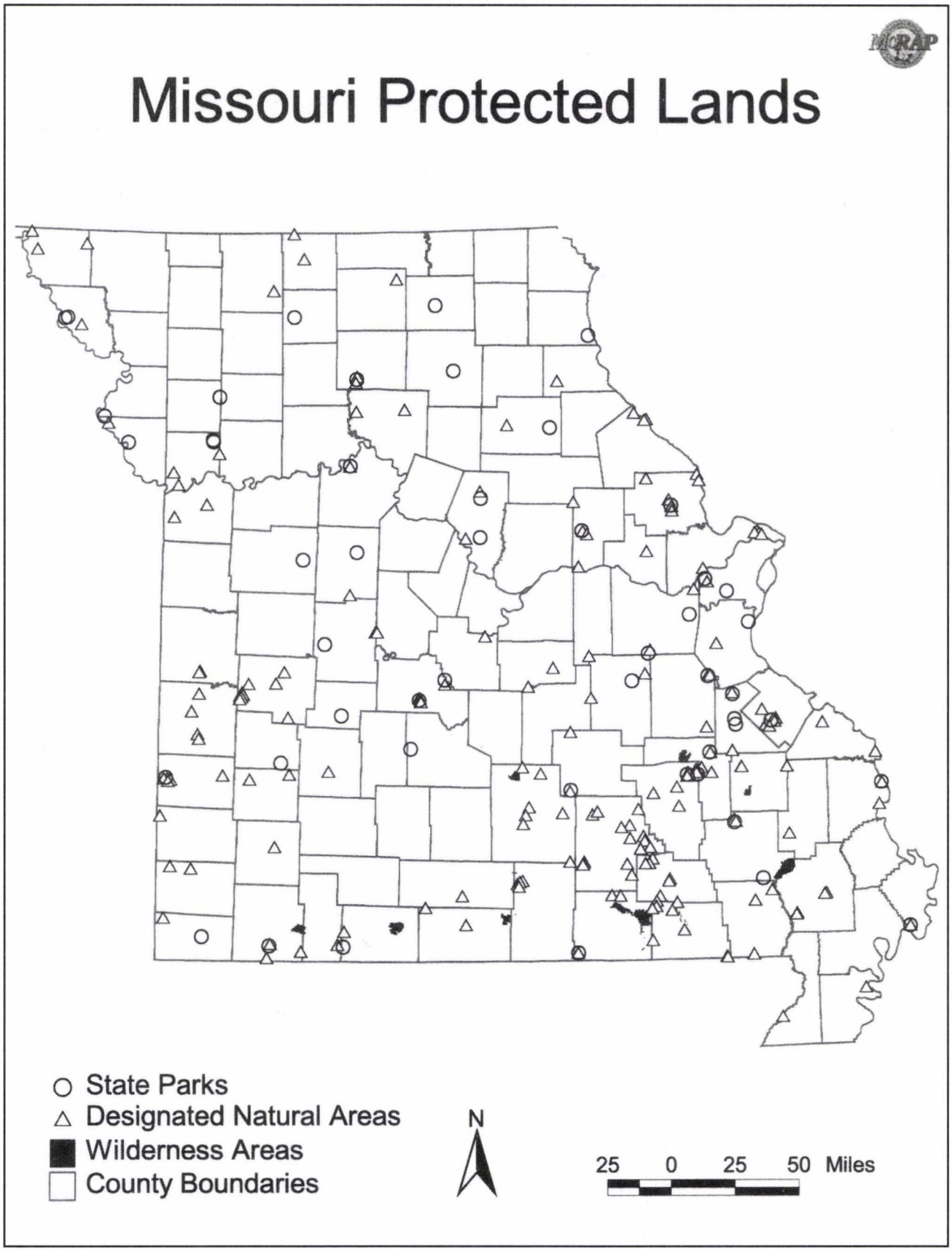


Figure 2.8—*Missouri protected areas—state parks, natural areas, and wilderness areas, 2000. Source: MORAP.*

of wilderness and an outspoken advocate of clearcutting. He would become the dominant force on the conservation commission for 12 years, during most of which forester Jerry Presley would serve as department director, and long-time executive director of the Missouri Forest Products Association Gerald Ross would serve as chief of the forestry division and then assistant director. During those years, the forestry division of the conservation department would remain staunchly committed to even-aged management of state forests even as the Forest Service, under intense public pressure, would begin returning to uneven-aged management on the Mark Twain. But during those same years, individuals in all agencies, federal and state, including the conservation department, would engage in a veritable orgy of planning and new initiatives spurred by the burgeoning public and professional interest in conservation biology, restoration ecology, and ecosystem management.

Ecosystem management and the related concepts of conservation biology and restoration ecology were not new—they date back at least to Aldo Leopold's work in the Forest Service in the early 1920s (Flader 1994) and had been advocated continually since the 1960s by leading ecologists and environmentalists—but in the late 1980s, they finally began to penetrate federal and state land-managing agencies devoted until then to commodity-oriented concepts of sustained yield and multiple use. The change was literally forced—from without by public pressure and court decisions and from within by ecosystem-minded younger professionals. The National Forest Management Act of 1976, which opened the door to citizen participation in forest planning, was itself the direct consequence of a 1975 court decision—the Monongahela case—that led to the virtual cessation of clearcutting on eastern national forests until Congress acted to establish new guidelines for planning and management. Missouri, where the forest was younger because timber harvest and forest protection had come later than in the East, managed to escape the brunt of the nationwide controversy over clearcutting in the late sixties and early seventies. But in the late 1980s, when controversy mounted again, fueled by the Reagan-era push to "get out the cut" and environmental concerns about old growth and endangered species as symbolized by the spotted owl in the Pacific Northwest, Missouri would not escape.

In an effort to capitalize on, study, assuage, or forestall mounting interest in ecosystem conservation and biodiversity in the late 1980s, state and federal agencies, citizen organizations, and academics in Missouri began a welter of initiatives, each apparently initially discrete and spurred by its own key proponents, that would become increasingly intertwined by the early 1990s and then, in several cases, evaporate or explode by the mid-1990s. It is virtually impossible to sort out the chronology of origin of all the initiatives, most of which seem to have begun around 1988, but they include environmentalist appeals of national forest timber management plans, an initiative petition for a Missouri Natural Streams Act and an alternative MDC Streams for the Future program, an ambitious forest planning effort by the Missouri Forest Resources Planning Committee, an effort to win designation of an Ozark Highlands Man and the Biosphere Reserve, a state biodiversity task force, a new statewide interagency partnership for resource assessment, a major study of Missouri forest ecosystems, a reorganized planning and management structure for conservation department lands, and the rise of a "wise use"/property rights movement in Missouri.

Environmentalist scrutiny of national forest plans in the Ozarks was triggered in early 1988 when rural residents petitioned against clearcutting in the Willow Springs district of the Mark Twain. A small but effective Mark Twain Forest Watchers group formed to apply leverage through planning and appeals processes provided by federal legislation and the recently released Mark Twain Forest Plan (Dorst 1993). Insisting that environmental assessments had to be site specific and that the effects of uneven-aged as well as even-aged management should be assessed for prospective timber sales, they successfully appealed and won a new systemwide management directive to that effect from the Chief of the Forest Service. The following year, 1990, probably as a result of management appeals nationwide as well as changing views among professionals within the agency, the Forest Service shifted to promote what they called "new perspectives" forestry, reflecting a changing emphasis toward an ecosystem approach (USDA-FS 1991a). When the Ouachita National Forest in neighboring Arkansas was designated a "new perspective" forest with a moratorium imposed on the use of clearcutting, conservation department director Jerry

Presley on August 17, 1990, fired off a letter of protest to Forest Service Chief F. Dale Robertson expressing his fear that the decision had been based in part on "the emotionalism of ill-informed preservationists" and asking that his department be advised in ample time to provide input if any similar action was contemplated for the Mark Twain. His widely circulated letter, coupled with statements from commission chair John Powell that environmental organizations were the greatest problem facing the conservation movement, stirred heated debate in the fall of 1990 (Powell 1990, Pryor 1990) and unsuccessful efforts to prevent the reappointment of Powell when his term expired in 1991. Though there was no moratorium on the Mark Twain, appeals by several environmental organizations resulted in a shift in harvest method from 70 percent even-aged and less than 1 percent uneven-aged sale acres in 1988 to a more balanced 29 percent even-aged and 32 percent uneven-aged in 1991, as reported by the Mark Twain (USDA FS 1991b).

The tension between environmentalists and the conservation department in the fall of 1990 was undoubtedly exacerbated by a vote that November on a natural streams act, which supporters called "the greatest unfinished piece of conservation business in Missouri." Placed on the ballot by initiative petition in a campaign funded in part by forest owner Leo Drey with wide support from environmental organizations, virtually all of which had earlier worked for the "Design for Conservation," it designated stretches of 52 streams on which dams, ATVs, loud motors, and bankside clearcutting would be prohibited and for which local governments and citizens could draft management plans enforceable by a new commission within the DNR. The conservation commission voted unanimously to oppose the initiative, citing potential interference with their own management prerogatives and a distaste for unnecessary regulation, and simultaneously approved a new program of their own, Streams for the Future, which offered money and technical assistance for voluntary efforts at stream improvement. Director Presley encouraged department employees to explain the commission's opposition to the Natural Streams Act to the public on official time and invited them to feel free to "oppose" the act on their own time (Presley 1990). The Natural Streams Act was resoundingly defeated by Missouri voters in November, in an election in which environmental initiatives nationwide went down to defeat, but proponents felt they had been undermined by the conservation department (Bradley 1996). In the aftermath, the department's own new program, showcasing voluntary "stream teams," grew to more than 1,300 teams with 26,000 members in its first decade (MDC 2000b), becoming recognized nationally as a model voluntary program.

During the years of tension over clearcutting and natural streams, an informal group known as the Missouri Forest Resources Planning Committee (MFRPC), which had been meeting intermittently since 1966 to discuss forest issues, began an actual comprehensive planning effort that led in 1991 to a "Forests for the Future" working conference in Jefferson City and production of *A Plan for Missouri's Forests*. The planning team consisted of representatives of four state agencies (Agriculture, Conservation, Economic Development, and Natural Resources), three federal agencies (Mark Twain, North Central Research Station, and Soil Conservation Service), the University of Missouri School of Natural Resources (so renamed in 1989 after transfer of Parks, Recreation, and Tourism to Forestry, Fisheries, and Wildlife), four professional or trade groups (Society of American Foresters, Consulting Foresters, Tree Farm Committee, and Missouri Forest Products Association), and one citizen group (the Conservation Federation), a composition that met with some suspicion by other excluded citizen groups. The committee identified issues and trends of concern and adopted goals, then invited conferees to discuss action items, and subsequently assigned lead and supporting organizations to work on each item. Many of the actions were initiatives already underway in the various agencies, but they were given an imprimatur and greater coherence by the plan. The intent was for the MFRPC to monitor progress and institute a followup planning effort in about 5 years. The following year, in March 1992, the Sierra Club and Southeast Missouri State University, in concert with the Mark Twain, MDC, and Four Seasons Audubon Society, hosted a major conference, "Towards a Vision for Missouri's Public Forests," to give voice to a broader array of groups, each with its own preferred directions for Missouri forests (Journet and Spratt 1992).

Other forest initiatives that began in the late 1980s had yet other points of origin. A National Park Service official at the Ozark National Scenic Riverways, David Foster, attended a Man in the Biosphere meeting in Kentucky in 1988 at which he was encouraged to develop a nomination for a biosphere reserve in the Ozark Highlands. Aware of the extraordinary biodiversity of the Ozarks and the economic and environmental benefits that such a prestigious designation could bring, he enlisted other groups, including the Mark Twain, MDC, DNR, The Nature Conservancy, Pioneer Forest, and similar entities in Arkansas in a planning effort that would involve intermittent meetings over the next 5 to 6 years.

Meanwhile, MDC director Jerry Presley and the supervisor of the Mark Twain, B. Eric Morse, acting apparently on suggestions from their natural history staffs, invited a team of scientists to define, describe, and make recommendations regarding the biodiversity of Missouri to develop a better basis for site-level ecosystem planning in the two agencies. The biodiversity task force issued its report in 1992 (Nigh *et al.*), recommending establishment of a council to coordinate the conservation of biological diversity in Missouri, including adoption of an ecological classification system, establishment of a central biodiversity database and geographic information system, and development of regional plans. From this effort grew a Missouri Biodiversity Council composed of the heads of 11 state and federal agencies, an effort to devise an ecological classification system for Missouri based on a national ecoregion framework developed by the Forest Service (Schroeder and Nigh 2002), a well funded interagency Missouri Resource Assessment Partnership (MoRAP) to coordinate statewide mapping, cataloging, and analysis of natural environmental features that has itself become a national model for geographic information systems, and a new interagency coordinated resource management effort for the development of regional plans.

And, from discussions in the late 1980s between a University of Missouri biology professor, John Faaborg, who was concerned about the effects of forest fragmentation on neotropical migrant songbirds, and several wildlife researchers in the conservation department came the most audacious effort of all. Casually dubbed the "100-year experiment," the Missouri Ozark Forest Ecosystem Project (MOFEP) began in 1989 with strong logistic support and research funding from the forestry division for a series of nine approximately 1,000-acre study sites, three each to be managed by even-aged, uneven-aged, and no-harvest treatments. The highly interdisciplinary study involves cooperation among more than 50 investigators in MDC, the Forest Service, and several universities to provide baseline data and then measure the impact of harvest treatments on a wide array of biotic and abiotic ecosystem attributes (Brookshire and Shifley 1997).

Within about 5 years, the biosphere, biodiversity, and MOFEP initiatives were bearing fruit in a remarkable array of cooperative interagency ventures. The Mark Twain had worked its way out of its clearcut controversy by its new openness to selection logging, and the conservation department had renamed all its forest and wildlife lands as "conservation areas" and had begun moving toward more integrated, regionally based management though still primarily even-aged. With the new trend toward ecosystem management in the Forest Service and other federal and state agencies and the flowering of interagency cooperation in Missouri, the conservation department in 1994 undertook yet another initiative, Coordinated Resource Management (CRM), inviting the DNR, the Forest Service, and other state and federal agencies to join in a series of public meetings in various regions of the state to develop ecoregional plans that could better provide for the long-term health and diversity of the state's resources (MDC 1994, McKee 1995). So promising was the interagency cooperation in this endeavor that leaders of the Missouri Forest Resources Planning Committee decided in 1995 to disband their ongoing forest plan efforts in favor of the new CRM process (Brown 1995). The first of the new draft plans was for the lower Ozarks region.

Then came a backlash out of the Ozarks. Though it took the form of public meetings and protests against the least well developed of the new initiatives, the Ozark Man and the Biosphere nomination, it killed or took the steam out of other interagency efforts as well. The controversy surfaced in early 1995 after property rights activists noticed an obscure reference to the biosphere project in a conservation department publication about the CRM initiative; by March an advertisement appeared in an Ozark newspaper about a

conspiracy to confiscate Ozark land. Within little more than a year, one agency after another began withdrawing support from the biosphere nomination. But, ironically, the public controversy peaked in late 1996 and early 1997 after the biosphere proposal was already dead (Goedeke and Rikoon 1998). It was then that speakers at large public meetings sponsored by organizations such as the Missouri Farm Bureau, People for the West, and Take Back Arkansas began warning of black helicopters from the United Nations moving in to herd Ozarkers into concentration camps in an effort to implement an environmentalist world government.

The larger context for this backlash was the organization in the late 1980s of the "wise use" and property rights movements in the West (Brick and Cawley 1996) and their extension into Missouri in the early 1990s at a time of controversy over exploratory drilling for lead in the Eleven Point River area, all-terrain vehicle trails on the Mark Twain, and horsepower limits for motors on the national scenic riverways, on all of which Missouri environmental organizations won initial victories (Midkiff 1994). The new "wise use" organizations, with officers and funding largely from the mining industry, were emboldened by the stunning national victory in November 1994 of Republicans with their Contract for America emphasizing property rights and limited government. Though the number of activists in Missouri was probably quite small, they were extremely effective in their use of the Internet and other organizing techniques and they appealed to Ozarkers' traditional distrust of government. When wildlife manager Jerry Conley from Idaho took over as director of the conservation department on the retirement of Jerry Presley in January 1997, at the height of anti-biosphere sentiment in the Ozarks, one of his first official acts was to pull the plug on the interagency Coordinated Resource Management program. Conley knew the wise use movement all too well from his days in Idaho and did not want to give it any further ammunition; instead, he began internal restructuring for a more integrated team approach to management of the department's own lands. Interagency cooperation continued quietly through MOFEP, MoRAP, and other necessary consultation, but to many who had envisioned a promising new era of cooperative ecosystem restoration in Missouri the wind had gone out of the sails.

Into the partial vacuum resulting from the demise of the Forest Resources Planning Committee, the biosphere nomination, and the CRM process, and even more from the property rights-induced timidity of the agencies, moved a major new factor in the forest equation—the state's first two high-capacity chip mills. Viewed by some as a significant new market opportunity and by others as the greatest threat to the integrity of Missouri's forests since the ravages of the lumber industry a century earlier, the two new mills, Willamette and Canal Wood—each capable of devouring more than 10 times as much wood as an ordinary sawmill—seemed a portent of more to come, since 140 such mills had already begun operating elsewhere in the Southeast. The threat was not so much from the milling operations as from the demand they would place on timber from private lands and the incentive they would offer, in one of the few states without any forest practice regulatory programs (Ellefson *et al.* 1995: 24), for landowners to profit from stripping the land. With the conservation department and many professional foresters seemingly favorable toward the new mills, environmental interests appealed to Governor Mel Carnahan, who responded with an Executive order in September 1998 establishing an advisory committee on chip mills and ordering state agencies to refrain from providing any further incentives to chip mills until the committee reported. About a month later the Ozark Chapter of the Sierra Club, which had been concerned for years about heavy clearcutting on MDC lands and in particular on more than 60,000 acres recently acquired from Kerr-McGee through The Nature Conservancy, released a detailed report (Hansen 1998) critical of MDC forestry practices. Also that fall, in response to heightened public concern about private forest management in Missouri, the Environmental Studies Program at the University of Missouri convened a broad-based planning group to organize a sustainability and public policy conference, "Toward a Vision for Missouri's Private Forests," to be held in March 1999.

The deliberations of the Governor's committee, which were conducted in the most open process of public participation ever devoted to forestry issues in Missouri, together with the sustainability conference and considerable

attention in the media, shifted the focus of the forestry debate in the state to the management of private lands and the need for public policies to encourage sustainability. Though the volume of growing stock in Missouri's forests had increased by a full 50 percent between the last two forest inventories in 1972 and 1989 (Hahn and Spencer 1991)—largely as a result of rapid regrowth following earlier harvests coupled with relatively limited availability of sawtimber for current harvest—the annual harvest for wood processing had mounted during the 1990s, even before the advent of the new chip mills, to 140 million cubic feet (Piva *et al.* 2000), which if converted to a board foot equivalent surpassed the highest recorded harvest in 1900 (fig. 2.1). Woodland values had been increasing so dramatically—largely as a result of demand for private land for deer and turkey hunting, homesites, and investment in north Missouri as well as in the Ozarks—that there were all too numerous examples of lands being stripped of marketable timber and then offered for sale to gullible buyers, usually urbanites, at prices little lower than the value of the land with the timber intact. Moreover, forest inventories revealed that Missouri had a far higher volume of wood in trees classified as rough or rotten—cull—than any other state in the nation, owing to poor past forest management practices as well as to relatively low site quality (Shifley 1999). Clearly, the 85 percent of Missouri forests that were privately owned needed far better management than they had received in the past (fig. 2.9).

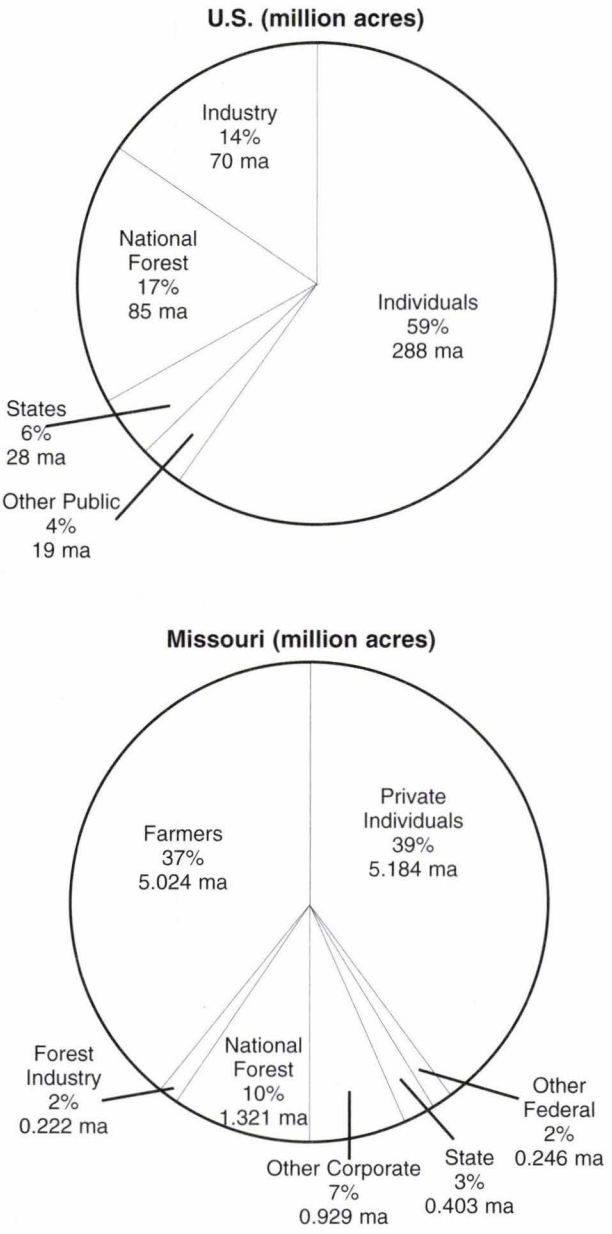


Figure 2.9—*Timberland area by ownership class, U.S. and Missouri, 1989. Source: USDA Forest Service statistics, GTR-RM-234, RB-NC-119.*

In an effort better to reach and serve private landowners, the conservation department reorganized yet again, creating a new private land services division to more efficiently provide the state's 300,000 private landowners with information, technical assistance, and cost-sharing funds (MDC 2000a). But the Governor's Advisory Committee on Chip Mills in its report (2000) proved unwilling to embrace any sort of regulatory mechanisms for better forest management, and the state legislature failed to enact any of the committee's recommended economic incentives (Lewis, this volume). Disappointed by the tenor of the chip mill committee's recommendations and the prospects for legislative action, a group of timberland owners, forest products firms, and environmentalists in the Ozarks established a new organization, Value Missouri, to work toward a nationally recognized certification system for forest land and wood products in the hope of encouraging market incentives for sustainable management (Value Missouri 2001). Meanwhile, chip mill activity in Missouri temporarily slowed owing to a market downturn, but loggers who had invested heavily in new harvesting equipment for the chip market continued industrial-scale logging.

CONCLUSION

There are paradoxes in the forest history of Missouri. A middling state in its population and wealth and in the quantity of its forested acreage, Missouri enjoys perhaps the greatest biodiversity of any state in the nation and yet it also harbors by far the greatest volume of cull of any state. A state that historically lagged far behind most other states in providing for public forests and resource-managing institutions and many of whose citizens have long harbored a perennial distrust of government has yet experienced frequent and vibrant citizen action aimed at establishing and enhancing public conservation agencies that are today considered models nationwide. A state that has long placed reliance on its small private landowners and has among the highest percentage of its forested land in private non-industrial ownership of any state has yet been unwilling to regulate the use or management of those lands in any way.

The forest history of Missouri gives no cause either for abject pessimism or for easy optimism. Missouri *is* a diverse state, both in its landforms and biota and in the origins, political cultures, and values of its people. When it has assumed a leadership role, it is because its citizens have made it happen. When it has lagged, it is because its citizens have acquiesced. Whether the state can achieve sustainability in its forest resources and communities in the 21st century was still an open question at the close of the 20th. But one thing is certain—in spite of the inevitable dynamism of Missouri's ecosystems, nothing much will happen to enhance sustainability unless the state's citizens make it happen.

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Ecological Sustainability

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The stock of renewable natural resources that provide humans with the food and fiber that form the basis of our health and wealth can be viewed as analogous to an endowment. If our goal is to allow future generations to enjoy the benefits afforded by these resources, we should manage and nurture them such that future generations can live off the interest rather than the capital. If we reduce the capital, future generations will suffer a loss of interest.

An appreciation of ecological sustainability as the central tenet of natural resource management is becoming evident among resource managers in North America and throughout the world. Indeed, the committee of scientists that recently developed guidelines for U.S. national forest management policy through the next century demanded that policies and practices be based on ecological sustainability (Committee of Scientists 1999). In so doing, they acknowledged the dynamic nature, uncertainty, and inherent variability of forest ecosystems, as well as the cumulative effects of diverse forest impacts. Though rapidly gaining recognition, the idea of sustainable forestry is not new. Some years ago, Noss (1993) claimed "sustainability is the motherhood and apple pie of modern conservation." This emphasis is also reflected in recent publications from the USDA Forest Service (e.g., USDA 1999) and from the National Research Council (e.g., Ellefson *et al.* 1998).

In this discussion of forest ecosystem sustainability, we start from a global perspective by reviewing problems pertaining to the condition of and demands imposed upon forest resources, including a discussion of global warming. In the body of the paper, we present key components of ecological sustainability and explore issues related to ecosystem processes and the conservation of biodiversity. We close with a brief discussion of policy implications and provide a set of criteria and indicators that can be used to assess current forest management trends and the progress we are making towards achieving ecological sustainability. These criteria can also be used to assess the effectiveness of proposed policies and programs as potential promoters of ecological sustainability in forest management.

THE FOREST ECOSYSTEM IN A GLOBAL CONTEXT

Of the forest that once covered more than half the land surface of the planet (excluding Antarctica and Greenland), almost half is gone, leaving a little over 3 billion hectares, and the health of those 3 billion is declining. Only about 22 percent is *frontier forest*, i.e., large expanses ecologically intact and relatively undisturbed, about half boreal (mostly in Canada, Alaska, and Russia) and the other half tropical, most notably in the Amazon Basin (Abramovitz 1998a, 1998b).

Cleared forest has been replaced by agricultural land and urban development, as well as by secondary forest and forest plantations. In 15 years, the area of forest converted to plantation has doubled worldwide to 180 million hectares, producing lands that support neither the species array nor the ecological processes previously present. As a result, the United Nations Environment Programme (UNEP 1995) warned that the planet's biological foundations are eroding faster than at any time in the last 65 million years. Myers (1999), meanwhile, estimated that the world has lost 600,000 of its 10 million species since the 1950s.

The United States ranks fourth behind Russia, Brazil, and Canada in forest area, but its forests have been through some hard times since European settlement. The period of severe overexploitation and abuse that lasted until the early decades of the 20th century reduced our forests from over a billion acres in 1625 to some 732 million acres in 1920 (Johnson and Ditz 1997). As a result of the more prudent approach taken since the

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1920s, the forested area in the U.S. has not only held steady but has actually increased slightly, to 737 million acres. Productivity, meanwhile, has increased 3.5 times (Salwasser *et al.* 1993) and harvestable timber volume has grown from 11.8 to 21.6 billion cubic feet (Powell *et al.* 1994). Nevertheless, only 6 percent is frontier forest (Abramovitz 1998a), and productivity on the remainder has not increased in recent years while harvest has, with average diameter decreasing by 20 percent from 1976 to 1991. By 2010 there may be no forest older than 60 years on industry lands in the Pacific Northwest and little older than 35 years in the South on any private lands (Johnson and Ditz 1997). The mature and diverse forests encountered by the early settlers are now virtually gone, leaving forests that support fewer large trees and fewer species, and that yield diminished ecological services.

This national pattern has been exhibited in Missouri also. The Central Hardwood Region now largely supports fragmented, even-aged 60- to 120-year-old regrowth forest, with <1 percent pre-dating European settlement (Parker 1993). Harvest has increased dramatically in Missouri in the last decade and is now nearly equal to peak harvests around 1900.

Demands on the Forest Resource

Population projections developed by the United Nations suggest that worldwide population will probably grow from its October 1999 level of 6 billion to nearly 9 billion by 2050, the median prediction in a range from 7.3 to 10.7 billion. Globally, the only region in which population decline is predicted is Europe. In the U.S., population growth increasing from 274 million in 1999 to 349 million in 2050, is expected to keep us in third place overall among nations. The Central Hardwood Region, of which Missouri is a part, contains 25 percent of the U.S. population (Parker 1993). Both the global and national projections pose problems not only for forests but also for other resources (renewable and nonrenewable) worldwide.

Since 1950, demand for roundwood has doubled, and paper demand (now accounting for 50 percent of the global harvest) has increased fivefold; a further doubling is expected in the next 15 years. Since most consumption occurs in developed nations where populations are generally more stable, population increase alone does not account for projected increases in demand. Over 50 percent of the wood harvested (70 percent of the paper) is used by the 20 percent of the global population that lives in Western Europe, North America, and Japan. *Per capita* patterns in paper consumption reveal a global average of 46 kilograms, with a range from 3 kg among Indians, 24 kg among Chinese, 200 kg among Germans, and 232 kg among Japanese to 320 kg among those of us in the U.S. (Abramovitz 1998a). If the entire world consumed paper at the rate of the U.S., it would be using 7 times as much paper as now, and by 2050 this would increase to 11 times the current usage rate. Global forests, many of which are currently over-burdened and "exploited" unsustainably with harvest rates exceeding growth, simply could not support a global per capita rate of consumption equal to that in currently developed nations.

Globally, the U.S. has the highest national roundwood production at 491 million cubic meters (m^3). At approximately 1.9 m^3 per capita, this per capita production is exceeded only by Sweden (6.27 m^3), Canada (5.97 m^3), and Malaysia (2.79 m^3). However, since Americans consume nearly 2.26 m^3 per capita (Johnson and Ditz 1997), we are forced to import timber to meet our need. As a result of varying productivity of timberland and the reservation of millions of hectacres for wilderness, refuges, parks, and other areas, the U.S. has only 490 million acres of available timberland available and productive enough to support commercial forests. According to Johnson and Ditz (1997), current U.S. annual demand would require about 1.8 acres of sustainably managed forest (as generally defined below) per capita. This suggests (simplistically, we admit) that if we were self-sufficient, current timberland could sustainably support a population of only 272.7 million (491 million/1.8), fewer than currently live here.

Forest product consumption in the U.S. increased from 336 million cubic meters in 1952 to approximately 560 million cubic meters in the early 1990s, it is predicted to increase by about 7 percent to over 600 million cubic meters in 2020 (Haynes *et al.* 1995). If we were to maintain the current per capita consumption rate of 2.26 m^3, with its requirement of 1.8 acres, we would need 791 million cubic meters of timber products and

630 million acres of timberland by 2050. Given the availability of only 491 million or fewer acres of forest by then, the U.S. population of approximately 350 million will need either to utilize more forest or produce more per acre of timberland through more intensive management or will need to reduce timber consumption. Alternatively, and of equal concern, the U.S. might meet its timber needs by exporting unsustainable management to those nations that supply our demand and that might have weaker conservation laws than we do.

To illustrate the global problem, let us (again simplistically) generalize these patterns of consumption and required sustainable acreage to a global scale. Let us argue that people the world over advance economically to the standard of living, and thus wood consumption rates, of the United States. With a U.N. median global population estimate of 8.9 billion humans in 2050 and a sustainable forest product harvest rate of 1.8 acres per person per year, this population would need 16 billion acres of productive forest. Yet currently the planet supports only 7.4 billion acres. Clearly, if the economic aspirations of developing nations are to be fulfilled in any measure, we are facing a forest products crisis of global proportions. The only solution to this (absent dramatically increased productivity or alternative fiber sources) would have to be an average global per capita consumption below that which we in the U.S. now enjoy. The potential for timber to join oil and water as a natural resource promoting international conflict should be clear.

If this admittedly simplified argument is placed in the context of current and predicted patterns in forest productivity in the U.S., we find the potential for crisis to be even more severe. After decades in which growth constantly exceeded harvest (increasing at 2.7 percent per year from 1952 to 1991), Reid and Dower (1997) reported that the highest predictions for productivity increase over the next four decades are less than 1 percent per year. If such were achieved, productivity would exceed the estimate of Haynes *et al.* (1995) reported above. However, even though the most recent figures indicate that current forest growth markedly exceeds harvest (Powell *et al.* 1994), the pressure that a larger U.S. population will impose on consumption presents a serious long-term problem for the harvest/production ratio. Indeed, Johnson and Ditz (1997) echoed this concern when they reported that, excluding forests that are legally protected or where the productivity is below a commercially useful level, growth rates appear not to be increasing at their previous rates to the point that harvest may shortly exceed growth. This drop in the rate of increase in productivity, the probable decline in forest availability, and the probable increase in demand for forest products combine to pose a serious long-term threat to U.S. forests. U.S. consumers, in turn, pose a threat to world forests. Globally, people will demand more of everything that the forests provide, and globally, just as in the United States, this will largely have to come from a fixed or even diminishing forested area. However, improved management and intensive or plantation forestry, although the latter has negative potential consequences for biodiversity, may be mitigating factors addressing this specific problem locally and globally.

Missouri with its 5.4 million people and 14 million acres of forest should have the opportunity to be self-sufficient in terms of ecologically sustainable timber production (assuming 1.8 acres per person), but in fact Missourians currently consume far more timber products than they produce (Shifley, this volume). Moreover, states do not exist in a vacuum; pressure on Missouri forests is not limited to local, regional, or even national demand.

Even if we were to pretend that the U.S. exists in isolation, and we were to couple the increased U.S. population in 2050 unreasonably with a constant per capita consumption rate equal to that at present, we would still exert greater pressure on natural resources than is now the case. But, if we are to look pragmatically into the global future, we must factor in the reality of resource consumption. We must acknowledge that citizens of developing nations will continue to strive to enhance their material wealth to something approaching the standards enjoyed in developed nations, and this will entail increased resource consumption. To deny them fulfillment of such aspirations would not only be unjust, it would also potentially flirt with disaster from a national security point of view.

Global Climate Change

The condition of and demands imposed on forests worldwide are also at the center of the debate about global warming and the contribution of anthropogenic carbon dioxide, because climate change may place added stress on forests while forests may ameliorate warming by sequestering carbon dioxide and deforestation may exacerbate it. Predictions of the Intergovernmental Panel on Climate Change (IPCC 1995) suggest that global temperature may increase as much over the next few decades as it did in the 15 thousand years or so since the temperature trough of the last ice age, on the order of 3.6°F (2°C).

The current distribution of forests is a consequence of prevailing rainfall and temperature patterns combined with the soil conditions that have developed over centuries as forest species have colonized and succeeded in an area. Pollen counts in mud columns reveal that species movements to their current distributions, particularly during the warming that followed the depths of the most recent ice age some 18 to 20 thousand years ago, were very slow (Pielou 1991). This was partly because the climate change itself was slow and partly because of the limited capacity for rapid migration of populations of trees. A relatively rapid warming of the sort predicted by current models and attendant change in water availability could have profound consequences for forest health generally and for forest floral and faunal biodiversity particularly.

Among the potential forest problems attendant on global warming (Vitousek 1993, Johnson and Ditz 1997) are the following:

- Floral and faunal biodiversity will be lost.
- Species that cannot keep pace (either by adapting or moving geographically) with the shifting climate are doomed to be eliminated from the forest system.
- The most likely to survive are species with wide physiological tolerances and effective dispersal mechanisms (i.e., early-successional species rather than mature forest or old-growth species).
- In continental zones, where drought may already limit forest distribution somewhat, conditions might be pushed to the point where grasslands are favored.
- Increases in the frequency of storms could cause shifts in the age distribution of forests, influencing health and productivity.
- Some skeptics have argued that an increase in the atmosphere of the greenhouse gas, carbon dioxide, would enhance forest productivity. But the absence of any such productivity increase as the concentration has increased by 30 percent since the Industrial Revolution denies such a suggestion. Such events, furthermore, could change the competitive balance among tree species and alter forest composition.
- Higher temperatures will likely favor the biological processes of temperature-dependant cold-blooded insect pests, plant pathogens, and microbial diseases. Meanwhile, increased temperature might influence soil micro-organisms such that decay is accelerated, turning carbon sinks into carbon releasers.

In addition to their potential to suffer severely as a consequence of global warming, forest systems also serve as sinks of carbon and thus can offset some greenhouse gas emissions. If they were appropriately managed, therefore, forests could play a significant role in policies attempting to address the threat of global warming. Mitigation strategies would include planting trees on agricultural land and in urban areas, increasing timber productivity on managed timberlands, conserving carbon-rich old-growth forests, using wood for durable goods, and employing more environmentally friendly materials in place of disposable products (e.g., electronic communication rather than paper). The first 100 million tons in carbon benefits from modified forestry practices are relatively cheap, involving tree planting, and could serve as a stopgap measure, as well as provide many incidental non-carbon benefits.

Unfortunately, rather than using forests to ameliorate climate change, we find that each year the conversion of forest to agriculture and other human development activities releases an additional net 3 billion tons of carbon into the atmosphere (Trexler 1991). As a result, atmospheric carbon concentrations are out of balance and have risen by 30 percent in just 250 years since the Industrial Revolution. This trend cannot be reversed unless we reduce our appetite for fossil fuels and reverse the trend in deforestation, especially in the tropics. In

the short term, however, tree planting and sustainable forest management could slow or mitigate climate change (Trexler and Haugen 1995).

ECOLOGICALLY SUSTAINABLE FORESTRY

A review of the literature reveals an array of components that have been identified as critical to ecologically sustainable forest management (Leopold 1949, Brundtland 1987, Salwasser 1990, Gale and Cordray 1991, Lubchenko *et al.* 1991, World Conservation Union 1991, Kessler *et al.* 1992, Viederman 1994, Franklin 1993, Johnson 1993, Noss 1993, Robinson 1993, Salwasser *et al.* 1993, Kolb *et al.* 1994, Willers 1994, Goodland 1995, Jordan 1995, Johnson and Ditz 1997, Meffe and Carroll 1997, Reid and Dower 1997, Abramovitz 1998a, Primack 1998, USDA 1999).

We combine these components into an eight-point statement of what ecological sustainability should mean for forestry, public or private. Sustainable management will:

1. provide from the forests to current and future generations (in perpetuity) a wide array of goods and services in addition to wood products,
2. while protecting biodiversity;
3. maintain ecological processes and the ability of ecosystems to respond to disturbance and accommodate change while recognizing the ecological limits imposed by a planet with finite resources;
4. promote forest health and productivity;
5. prevent industrial pollution and waste, while promoting efficiency of resource use (reducing consumption).
6. In addition, sustainable management will sustain communities and ensure social justice by allowing equitable access to and consumption of natural resources.
7. Although the principles of sustainability do not prescribe management techniques, strategies and techniques employed will be socially responsible and will promote management of complete ecosystems.
8. Finally, ecologically sustainable management will acknowledge the intrinsic value of the natural world.

These components of ecologically sustainable forest management derived from our analysis of recent literature may be compared with the criteria for sustainable management of temperate and boreal forests developed through the international participatory seminar known as the Montreal Process and subsequently endorsed by the Northeastern Area State and Private Forestry (USDA Forest Service) and Northeastern States, including Missouri (USDA 1999):

1. Conservation of biodiversity
2. Maintenance of the productive capacity of forest ecosystems
3. Maintenance of forest ecosystem health and vitality
4. Conservation and maintenance of soil and water resources
5. Maintenance of forest contributions to global carbon cycles
6. Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies
7. Maintenance of the legal, institutional, and economic framework for forest conservation and sustainable management

As both sets of criteria listed above suggest, ecologically sustainable forestry will sustain human communities as well as biological diversity and the health and productivity of the forest. Indeed, although we sometimes think of forest ecosystems as natural systems unimpeded by human beings, in fact, it is impossible to remove humans from ecosystems. In the discussion of ecological sustainability that follows, we first consider implications of the inevitable human role in ecosystem processes and then we consider concepts and issues related to one of the most essential elements in ecosystem sustainability, the conservation of biodiversity.

THE INEVITABLE HUMAN ROLE IN ECOSYSTEM PROCESSES

When we think of *nature* or "natural systems," it is tempting to envision a pristine world in the sense of one "untouched by human hands," entirely unaffected by human activities, direct or indirect. The deepest realms of the Amazon forest, the high peaks and valleys of the Himalayan Range, even Missouri before the advent

of Europeans, come to mind. A moment's reflection, however, reveals that in reality there are no pristine natural systems in this sense remaining on the planet. Even the once most remote areas are experiencing the effects of either direct human encroachment or invasion by human-induced natural phenomena, e.g., the hole in the ozone layer above Antarctica, the greenhouse gases likely contributing to global climate change, and the like.

Even if there are no such pristine natural systems, it is helpful to begin this discussion by recognizing that this was not always the case, and to start with a time when such a situation was still possible. That is to say, let us consider for a moment an ecosystem in which virtually no human influence is experienced in terms of its ecological structure and functioning. Allen and Hoekstra (1994) discuss several important features of such a system, and what follows is a capsule summary of part of their much more extensive theoretical perspective (Allen and Hoekstra 1992).

Ecological theory directs our attention to the central structures and the functions they perform in carrying out critical ecosystem processes. An ecological system sustains itself not simply by persisting without change, for any whole material system cannot be sustained in its every facet. As Allen and Hoekstra note, "Life precisely works as a process of building up and breaking down materials and relationships. In all healthy biological functioning, things persist and grow because other things are not sustained." Thus we can say ecological sustainability is not simply the absolute or complete *persistence* of a given material or ecological system.

A second key point is that such a system sustains itself by interacting with—and more specifically, importing energy from—larger systems within which it is embedded, i.e., its environment. That environment is also, however, a source of disturbances, and the focal ecological system sustains itself by its ability to withstand and recover from disturbances. In this light, the concept of *resilience*, as opposed to mere persistence, is closer to the heart of what defines a sustainable system. A persistent system develops tolerances in terms of its ability to withstand (= resistance) and recover from (= resilience) different kinds of disturbances. Moreover, not only the system as a whole but also its components develop differential capacities to respond to disturbances; and since all system components are connected, the resilience of components ultimately affects that of the overall system. A system that can utilize all these capacities of its multifaceted components to recover from an overall disturbance is termed a *robust* system. Such a system in effect reaches a "moving equilibrium" with its environment, importing energy, exporting wastes, and reacting to external disturbances. Key natural influences that generally shape such ecosystems include climate, soil type, moisture, fire, storm, and biodiversity.

Continuing for the moment the assumption of a pristine ecological system, we may now recognize that for any such system, there may be a number of local components with narrow tolerances, making the overall system *fragile*. The failure of any of these local components with narrow tolerances could lead to a breakdown of the entire system. Fragile systems can break down in a variety of ways; they can collapse more abruptly and with fewer warning signs than more robust systems.

Now let us relax the assumption that we are dealing with a pristine ecological system and recognize the inevitability of human presence, direct or indirect, in virtually all ecological systems on the planet. As Allen and Hoekstra (1994: 103) continue, "When an ecological system is altered by human activity, it often becomes more fragile.... If fragile systems are to be as stable as robust systems, they will require more maintenance and planning.... Indeed, the whole discourse of sustainability through management action turns exactly upon how systems greatly changed by man can be maintained." History is replete with examples of societies that created fragile ecological systems, which subsequently collapsed due to human inability to muster the steady stream of high energetic inputs necessary to maintain those systems in their fragile state. Allen and Hoekstra continue with an example from ancient Greece:

> The role of the Greeks was to make their system fragile and dependent on their civilization. It fell apart when they were not there to maintain it.... On many criteria, such as faunal diversity, the system was drastically altered .... Development of agriculture caused

> significant removal of forests.... With a full human population to tend the terraces, the agroecosystem was stable; .... It might have been sustained until today but for outside pressures. While it did not make the system unsustainable, the human modifications of the classical Greek landscape had made it fragile.... [T]he ultimate destruction of the ancient ecosystem was the consequence of Romans taking slaves and reducing the population. With too few people to tend the fragile landscape, [the soil] washed off into the sea....

To reiterate an important point, human modification will often lead to ecosystem fragility, although fragility does not mean that the system is unsustainable.

What might happen to such fragile systems, especially if human influences on them are intensified? Scientists and conservationists have attempted to describe the potential effects of these processes in a number of ways. Frequently they take the form of metaphors that, by nature simplified and thus in many ways imprecise, attempt to capture the essence of the phenomena described. Stevens (2000) describes two ecological metaphors most frequently applied to the fate of fragile ecological systems continually modified by human influences. We may call these the metaphors of the rivets and the tapestry.

In the metaphor of the rivets, an ecosystem is likened to an airplane. Each severe environmental destruction or alteration—e.g., the extinction of a plant or animal species—is akin to removing a rivet from the plane. Initially, the effects are minimal, given the large number of rivets. But if enough rivets are removed or a few are taken away at crucial spots, the plane will crash. This metaphor posits the existence of limits or thresholds beyond which increasing pressure suddenly precipitates a catastrophic ecosystem collapse.

In the second ecological metaphor, the biological world is seen as a rich, diverse tapestry. Ultimately reliant on solar energetic inputs, the ecological tapestry weaves its own elaborate pattern of energy-driven processes and structures. Each act of environmental destruction by humans equates to pulling a thread from the tapestry. At first, the results are almost imperceptible. The function and the beauty of the tapestry is slightly diminished with the removal of each thread. However, if too many threads are pulled—especially if they are pulled from the same area—the tapestry will begin to look worn and tear locally. In this metaphor, there is no clear threshold of catastrophe, but rather a "continuum of degradation" from "a world rich in biodiversity to a threadbare remnant with fewer species, fewer natural places, less beauty, and reduced ecosystem services" (Stevens 2000).

As with all metaphors, each of the above amplifies one or more central facets of the phenomenon it represents while simplifying others. With respect to the metaphor of the rivets, for example, and focusing on biodiversity as one of the critical factors affecting ecological sustainability, it is widely recognized that the sustainability of ecosystems depends at least partly on the varieties of species they contain, but it remains unclear at what point a collapse may occur when species are gradually removed. Moreover, it is not entirely clear what would constitute an ecosystem collapse. For example, would it happen when an exotic species of weed has driven out all other plants and their animal dependents? Or would it occur when all life is obliterated?

Other kinds of questions are not sufficiently encompassed by the tapestry metaphor. Thus, for example, if human influences on natural systems are as pervasive as many scientists believe, such wear and tear involves more than simply fraying the tapestry. Rather, humans are reweaving it into entirely new patterns, with a new mixture of colors and a new texture. And while the new pattern may even appear coherent, it may be markedly simpler, duller, and less functional than the original. Some ecologists also point out that the tapestry metaphor conveys the notion that nature is in a static state, when it is actually in a continual dynamic flux. Tearing the fabric sends "waves of dynamic change through an ecosystem, and the waves get bigger as biological diversity declines" (K. McCann, quoted in Stevens 2000). This draws attention not simply to the potential for the collapse of ecosystems, regardless of the current uncertainty as to how and when such events might occur, but also to the tragedy that is actually unfolding as humans simplify their world on an unprecedented scale. Whether viewed in terms of the intrinsic value of nature worthy of sustaining for its own sake, or, in a more

anthropocentric vein, the loss of aesthetic, spiritual, and other experiences that are an integral part of the richness of human life, what is happening is something more than simply enhancing the potential for an ultimate system collapse.

It is evident that each of the metaphors—of rivets and of tapestry—captures key aspects of human influences on fragile ecological systems. However, in enriching our understanding of these systems, they also suggest other problems that scientists have recognized to be in need of resolution before we fully understand all the processes involved. Allen and Hoekstra (1994) point out that forests and other ecosystems become fragile because humans, in the process of altering the system for their own purposes, remove part of its ecological context, replacing some of the key ecosystem functions performed by various ecosystem structures. The idea of *management* reflects human efforts to maintain such a system in a state they desire by directing the system to where they want it to be. Since that state is not where the system would go left to its own devices, management—and ultimately sustainability—means maintaining the critical functions of the "natural" system to perform the services normally provided by the now-removed context. In the above example of ancient Greece, the alteration of the context was the removal of the forest. The problem was an inability of the society debilitated by slavery to continue to perform the functions of the forest, such as soil conservation.

Another way to phrase this is that human modification of ecosystems often amounts to moving and keeping such a system away from the equilibrium that would prevail if the system were unmodified. This, however, invariably requires substantial inputs of energy (appropriated from the system itself) to allow humans to continue constantly grooming and applying fine-grain adjustments to the system. In ancient Greece this was the constant tending of terraces that retarded erosion, and the weeding of woody plants that, left to grow, would lead back to the forest through succession. Allen and Hoekstra (1994: 104) summarize the general implications of such a situation:

> In structured systems that exist far from equilibrium, energy is dissipated particularly rapidly in the maintenance of the distinctive structure. If the high frequency control of the system is suspended, there will be rapid change as the system moves down a steep gradient, sometimes back to the primitive condition, but sometimes to something else.

In the case of classical Greek society, the system moved quickly to a condition where the unprotected soil washed away.

This leads to a general formulation of the concept of sustainability when applied to ecological systems in which a human presence is assumed:

> In efforts to achieve sustainability, dominant aspects of system behavior... [are modified] through enhancing high frequency, energy demanding activity. That activity fights the tendency to degeneration of the emergent structure. Such energy demanding systems with rapid internal functioning are now recognized as stable energy dissipating structures that exist far from equilibrium. They are the appropriate model for the nature of sustainable systems.

In less theoretical terms, Allen and Hoekstra are saying that when humans modify a predominately "natural" ecological system for their own purposes, they divert or channel significant amounts of system energy in directions it would not otherwise go if human influences were absent. It took a tremendous amount of energy to maintain the Greek terraces—human labor that replaced the natural processes of forest succession. Even today, human management usually entails short-term manipulation of ecological systems for human purposes, in contrast to more long-term dominant system processes. Thus, for example, we are constantly presented with evidence of successful forest management via producing the same amount of wood volume at shorter rotations—i.e., by postponing the dominant system process of succession indefinitely. This is achieved through "enhancing high frequency, energy-dependent activity." And that very energy—i.e., labor—"actively fights the tendency to degeneration of the emergent structure." In effect, the Greek terraces were indeed "energy-demanding" systems that were being kept in a state far from the natural dynamic equilibrium with their

environment that would have evolved if the dominant "natural" system process—i.e., forest succession—had been allowed to proceed without human modification. The terraces—as long as the high-energy labor inputs were provided—were, in effect, "stable energy dissipating structures that exist far from [their natural dynamic] equilibrium" in the sense that high levels of energy were required (and, ultimately, "dissipated" through the practice of labor) to keep the system in its contrived state.

This perspective of structured systems existing far from equilibrium has been found to apply to a variety of natural phenomena (e.g., whirlpools, convection cells that form the basis of thunderstorms). It has been found that when more energy goes through a system, such structures arise spontaneously and naturally. Allen and Hoekstra and others (see, for example, Kay 1991 and Kay and Schneider 1992) argue that in the modern world permeated by human presence, this is the appropriate framework for understanding ecological integrity, and that it is such far from equilibrium conditions that humans must accommodate.

Thus, ecological sustainability cannot be envisioned as the return to some mythical pristine past, desirable as that may be. Rather, it must evolve from recognition of where we are now—i.e., in a world in which human influences are pervasive and incapable of being erased. All major primitive ecological systems have already succumbed to diversions of their resources for human purposes, so a program of sustainability of humanly altered systems is the only course left. In an admittedly painful pragmatic vein, "from here on out" sustainability must be a process of evolution that incorporates humans and their institutions into a larger ecological system. In this new ecological arena, the human creature must pay its way in maintaining system structure, using its energy to sustain critical ecosystem processes, functions, and structural diversity in the course of both meeting basic human needs and sustaining the rich tapestry of the ecological world that is the source of beauty, spiritual sustenance, and a vast array of other experiences that make life worth living.

In terms of the ecological metaphors outlined above, the potential for rapid system collapse through movement down steep energy gradients has much in common with the rivet analogy. At the same time, it is also evident that the "structures" to which humans contribute and which they attempt to sustain may be recognized as ecological tapestries capable of preserving all of the richness and diversity that humans will allow.

The forests of Missouri have demonstrated their resilience in re-establishing themselves after the massive deforestation that occurred at the turn of the last century. From one metaphorical perspective, we might say that many rivets were pulled out, but that the system was able to hold together enough to continue without crashing. However, the human-induced disturbances to the forest ecosystem in Missouri differed in a number of ways from the example of the Greeks creating the fragile terraces, which may be recognized as the paradigmatic case of a fragile ecosystem created through human "management." In Missouri the forest was not entirely removed by humans, and it was able to re-establish itself after the timber boom ended. But from another metaphorical perspective, given the fraying of the tapestry and the massive impacts that reverberated through the system due to that major disturbance, the forest that came back was not the same. As Flader (this volume) observes, the shortleaf pine forests of the state, which once covered some 6.6 million acres in the Ozarks, were reduced to 600 thousand acres, with much of that a component of the oak-pine forest type. The Ozark soils, never deep in the first place, were thinned even more due to the erosion triggered by the massive harvesting during the boom. With old growth virtually eliminated, biodiversity was undoubtedly altered significantly, although we lack the systematically collected scientific data to confirm this categorically. In short, while the system was able to restore itself, it had become more fragile *and* rewoven into a different, less vibrant pattern due to the massive earlier human-induced disturbances. Moreover, not only during the boom but afterwards as well, humans continued to pull threads from that tapestry. Until after World War II, this was largely through the practices of farmers and other small landowners who highgraded their woodlots and continued to run livestock in the woods. Since then, the fabric has been further altered by heavy reliance on even-aged management techniques by public agencies and the gradual return of harvest levels to those of the peak boom years.

So, although the system did not crash, from another perspective a critical question might be what kind of tapestry was rewoven, both initially through the forest's natural ecological ability to recover from disturbances and subsequently through increasingly intensive human-induced modifications? Have colors been lost or blended into one another, designs simplified, and so on? What has been sustained and what has been lost in the process? And of more immediate concern, what do we want to sustain in terms of the interdependent relationship of ecological and human social systems that defines the fabric of the present and the uncharted terrain of the future? Humans will have a large say in how these questions will be answered, and, to the extent that their actions have modified the earlier natural configurations that existed in the Ozarks, the theoretical framework presented above suggests that in attempting to "manage" their overall influences on Missouri forests—both in terms of direct forest management and in "managing" the broader social processes (e.g., urban sprawl) that have so significantly affected the composition of our forests—human activities will have to be in line with and attempt to sustain the central ecological processes, energy flows, and gradients that are critical to the integrity of the ecological systems in which humans are embedded and which they have influenced so profoundly.

CRITICAL ISSUES IN THE CONSERVATION OF BIODIVERSITY

Recognizing the inevitable human role in ecosystem processes, humans are also fated to be involved in the conservation of biodiversity in order to maintain ecological sustainability. Three concepts exist under the umbrella of biodiversity. The most familiar of these is the concept of species richness, but biodiversity also includes genetic variability and habitat variability, all of which must be preserved if ecosystem processes are to be sustained fully.

Species richness refers to the number of species inhabiting an area. The concept is usually divided into three components: alpha, beta, and gamma diversity (Whittaker 1972, 1975). *Alpha diversity* is also known as point or habitat diversity. It refers to the number of species present at a specific point, location, or habitat; for example, one aspect or angle of slope of a valley, the valley floor, or the ridge. *Beta diversity* refers to the turnover in species from habitat to habitat; for example, the change in species from slope to valley floor to ridge. *Gamma diversity* refers to regional or landscape diversity; it is a consequence of the patterns in alpha and beta diversity over all the habitats in a large area.

Genetic variability refers to patterns of genetic difference that occur among individuals and, particularly from a conservation point of view, among different populations of the same species over the geographic range occupied by the species. Through genetic diversity, different populations of a species become adapted to the different or unique local environmental conditions. Additionally, it is the genetic variability within and among populations of species that allows them both to recover from short-term disturbances and to respond to long-term environmental change (such as climate change). Protecting the genetic diversity of species requires maintaining more than a few representatives to sustain a captive breeding colony. Rather, it requires maintaining substantial numbers of organisms with the minimum required varying with biological and genetic characteristics of the species (Meffe and Carroll 1997, Primack 1998). For species such as grizzly bears or wolves that are intrinsically rare because individuals use large home ranges, maintaining viable populations could require managing hundreds to thousands of acres of habitat for each conserved population.

Extending out from the individual, population, or species, we find the third component of biodiversity—the spatial variability at a broad landscape or regional level that results in different patterns in the geographic distribution of species. This ranges in dimension from diversity of local habitats through local community and regional ecosystem or biome diversity. In delineating the natural divisions of Missouri, for example, Thom and Wilson (1980) identified a series of six broad geographic regions in the state, with a total of 17 sections. Nelson (1985) extended the concept by classifying the terrestrial natural communities of Missouri in a system with 26 forest community types and another 6 savanna types. The ecoregion classification system of Bailey (1998) delineated the major ecological systems of the U.S. An earlier version of this was modified by The Nature Conservancy to

identify 63 distinct biological ecoregions in the United States, of which 5 occur in Missouri (TNC 1997). Nigh (this volume) has shown how the system of Ecological Landtype Classification applied to Missouri reveals the existence of a vast array of local assemblages of flora, each supporting characteristic components of biodiversity. To maintain biodiversity, such a classification system should form the basis for policy development and management planning in the state.

Also integrally involved in the concept of biodiversity are functional or process diversity, and, particularly for forest systems, structural diversity. Functional diversity deals with patterns in such processes as water and nutrient cycles, energy pathways, and predator-prey interactions. Structural diversity, meanwhile, addresses the structural layers (such as emergent, canopy, subcanopy, understory, shrub, and herb) typical of forest systems, which vary both spatially and temporally (Sharitz *et al.* 1992).

Missouri exhibits significant biodiversity of all types, as described by the Biodiversity Task Force (1992). With its location near the center of the continent on the border between tallgrass prairie and oak-hickory woodland and at the confluence of three major river systems—the Missouri, Mississippi, and Ohio—that serve as routes of dispersal and corridors for migration, the state harbors a high degree of species richness. Its Ozark Highlands, which have been above sea level and available for colonization for more than 200 million years, have experienced great climatic variability coupled with exceptional geologic and physiographic variability that have made them one of the great centers of genetic diversity and biological endemism on the continent. And its Ozark border, glaciated and unglaciated plains, big rivers, and Mississippi lowlands, while not as biologically diverse as the Ozarks, contribute to Missouri's remarkable habitat and community diversity.

Among the issues of greatest concern in the conservation of biodiversity in Missouri, as elsewhere, are rarity, or the vulnerability of species to extinction; a tendency to emphasize early stages of succession in current forestry practice; and the vexing division of habitat into smaller and more separated patches, or fragmentation. The net result has been a decline in biodiversity, forest health, and the capacity of forests to provide a range of non-timber ecosystem services.

Rarity

In exploring issues pertaining to species vulnerability, we should note that, for many species, rareness is not induced by human actions but is an inherent characteristic. Thus, if we consider the geographic ranges of species, we find some occupy a large area and others a small area. In terms of habitat specificity, some species can occupy a wide range, while others can use only a narrow range. Finally, in terms of population size, some species have a large population at least somewhere, while others naturally have small populations everywhere. A review of this set of attributes will reveal that only those species occupying a wide range, with broad habitat requirements and a large population somewhere, will be common. All other combinations will lead to species that are naturally rare (Meffe and Carroll 1997). Local rarity may also be a consequence of a species existing at the edge of its normal range and limits of environmental tolerance, when it might be relatively common elsewhere.

Whether populations are small because of their natural attributes or because of human activities, one consequence of small population size is an increased probability of chance extinction (Meffe and Carroll 1997, Primack 1998). Extinction might be induced by natural events such as an extreme climatic abnormality decimating a population. It might also be induced by human activities directly reducing population size by harvesting individuals, or by eliminating habitat and thus the individuals it supported. When considering the impact of management on biodiversity in a given locality, it is important, therefore, to consider to what extent species in question might be inherently rare regardless of human activity. Although species that are rare in Missouri may occur elsewhere, we can be lulled into a false sense of security. If habitat depletion occurs in all states where a species exists, even a common species can quickly fall in numbers to threatened levels. Human activities can even more rapidly become critically detrimental to naturally rare species.

Succession and Forestry

As natural communities recover from a severe disturbance, they generally pass through a succession of stages during which changes occur in species composition and in many components of community structure and function. An inspection of biomass accumulation during succession reveals that it accelerates and then levels off asymptotically as the forest matures (fig. 3.1). To maximize the rate of timber yield, the forest manager therefore should keep the trees young, where biomass accumulation (growth) is highest. Unfortunately, when we consider species richness in forest ecosystems during succession, we find that the optimal age for timber harvest occurs before the peak for maximal species richness. The younger forest valued by the timber harvester is also exactly where the forest supports its lowest species richness (i.e., less biodiversity). Mature and old-growth forests support greater biodiversity (fig. 3.2). The loss of older components in forest systems threatens biodiversity throughout the world (Martin 1991). The lesson seems to be that the forest manager focusing solely on sustainable yield of timber is unlikely to provide an ecosystem that promotes regional ecosystem biodiversity. This distinction may explain a paradox in perceptions about the sustainability of current practice: many foresters are convinced that they are practicing sustainable forestry, even as biodiversity declines and ecological processes are threatened. Timber yield sustainability and ecological sustainability appear not to be equivalent.

Since the 1600s, the impact of humans on the distribution of what has been called virgin forest has been severe, leaving but a fraction of a percent standing (Moore *et al.* 1996). Probably this would better be called "old growth" since most U.S. forests were first managed centuries ago by Native Americans (Sharitz *et al.* 1992, Parker 1993). Noss (1993) pointed out that in the early 1800s, forests in the Pacific Northwest were 60 to 70 percent old growth, while forests in the east were only 50 percent old growth. The old-growth percentage for the Northwest is now down to some 10 percent, with generally lower values elsewhere. It is little wonder, then, that many conservation-minded critics question management targets for old growth that fall in the 10 percent range when ecologically sustainable management is claimed as a goal.

In Missouri, as elsewhere, many current forestry practices tend to favor early stages of succession in the forest. Such habitats are home to 38 of the species of conservation concern on Missouri's State list (MDC 1999). Although more enlightened forest management plans currently incorporate percentages of old-growth forest, as indicated above, these are often well below the historical proportion. Unfortunately, habitats such as mature or old-growth forest that are reduced by conventional forestry are home to a much larger number, 125, of our listed species. As table 3.1 suggests, forest management in Missouri does not seem historically to have had a positive impact on biodiversity.

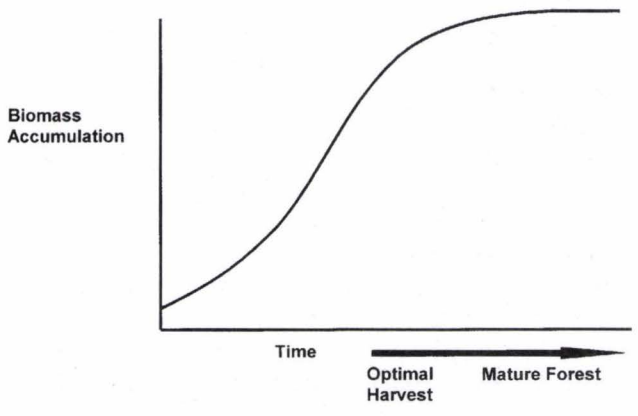

Figure 3.1—*Model of biomass accumulation during forest succession (modified from Odum 1997).*

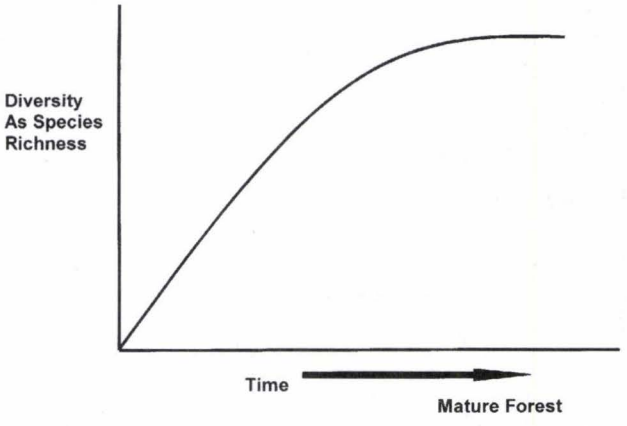

Figure 3.2—*Model of increasing species richness during forest succession (modified from Smith 1996).*

Fragmentation

The division of habitat into ever smaller and more separated patches has become an increasing concern to conservationists since the development over 30 years ago of the theory of island biogeography. Because of the pattern in the distribution of individuals among species in natural habitats, we find that species richness increases asymptotically as the area sampled increases. Macarthur and Wilson (1967) explored patterns in species richness on oceanic islands. They argued that as a consequence of the balancing rates of immigration of species from colonizing sources and the chance extinction of established resident populations, equilibrium in species richness would exist on an island. According to the theory, this equilibrium number should vary according to island size and island distance from colonizing sources. As indicated in figure 3.3, islands that are large and near a source of colonizers will have higher rates of immigration than will those that are small or far away. Meanwhile, smaller islands, which will support smaller populations of resident species, will have higher rates of extinction than will their larger counterparts. Data have frequently supported the theory, whether they were collected from oceanic islands or continental islands of favorable habitat in a sea of unfavorable habitat.

When we compare further the number of species on islands with the number supported by an area on the mainland of equivalent size, as figure 3.4 indicates, we find a pattern that

Table 3.1—*Forested habitats of Missouri indicating the number of State listed species present (from MDC 1999)*

HABITAT TYPE	# Species
Habitats tending to be promoted by conventional forestry	
Forest-field edge	14
Immature hardwoods (poles/saplings 3" – 9" d.b.h.)	7
Oak-Hickory regeneration (0 - 3 years)	6
Oak-Hickory regeneration (3 - 10 years)	6
Shortleaf Pine reproduction (0 - 3" d.b.h.)	5
HABITAT TYPE	**# Species**
Habitats tending to be reduced by conventional forestry	
Mature Oak-Hickory (9 +" d.b.h. open understory)	14
Mature Oak-Hickory (9 +" d.b.h., dense understory)	20
Oak-Hickory old growth	16
Mature Shortleaf Pine	14
Shortleaf Pine old growth	12
Swamp	22
Wooded Riparian and Bottomland Forest	27

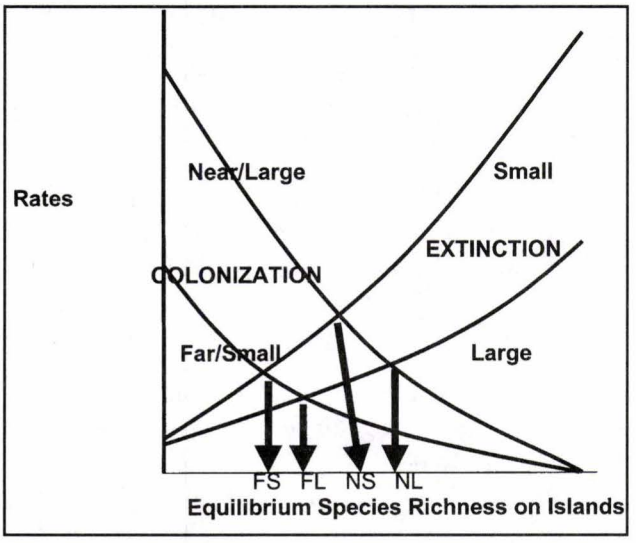

Figure 3.3—*Model of equilibrium species number on islands in relation to island size and distance from colonizing source: FS = Far/Small, FL = Far/Large, NS = Near/Small, NL = Near/Large (modified from Meffe and Carroll 1997).*

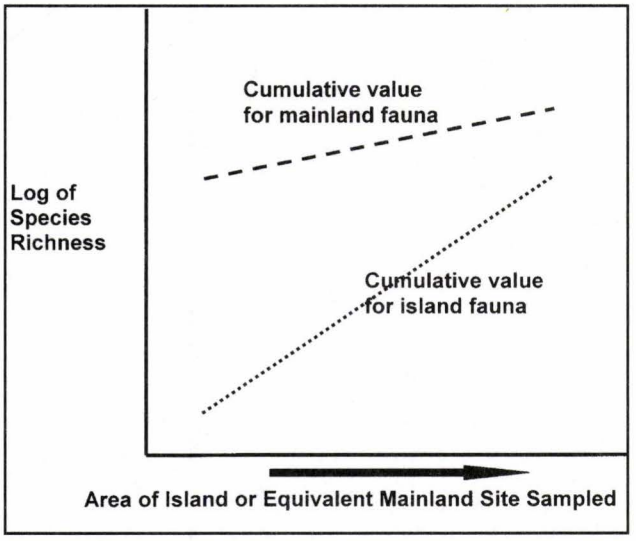
Cumulative value for mainland fauna
Log of Species Richness
Cumulative value for island fauna
Area of Island or Equivalent Mainland Site Sampled

Figure 3.4—*Species area relationships comparing species richness on islands with mainland sites of equivalent area (adapted from Begon* et al. *1990).*

is particularly relevant to conservation planning. This comparison indicates that islands support fewer species than mainland areas of equivalent size. The overall consequence of this pattern is the principle that a 90 percent reduction in habitat patch (fragment) size is likely to lead to a 50 percent reduction in the number of species supported by that patch (fig. 3.5). This is the reason that fragmentation poses such a threat to biodiversity. Additionally, we can see that fragments more distant from a colonizing source are greater threats to their inhabitants. The lesson for conservation has been quite clear for many years (e.g., Slatyer 1974). On a global basis, fragmentation of habitat into smaller and more isolated patches is one of the most conspicuous consequences of the forest management practices we have used to date.

Compounding fragmentation is the problem of *edge effects*. Suppose that a forest patch is square, with sides 1,000 m long. In this forest system, suppose further, the edge effect extends 100 m into the forest. The one km square patch of forest contains 1,000,000 m^2 (100 ha) of forest. But because of the loss of 100 m from each edge, the core forest area is only 800 x 800 m, for a total of 640,000 m^2 or 64 ha. Now, suppose that two roads are constructed to bisect this patch, passing perpendicularly through the middle, each with 100 m of deforested easement (fig. 3.6). The patch is now divided into four equal fragments, each 450 x 450 m in area or 810,000 m^3 (81 ha). Because of edge effects, however, each of these smaller patches actually contains only 250 x 250 m of core forest, for a total core forest area of only 250,000 m^2 (25 ha). The roadways, therefore, have reduced the total forest area to 64/100 = 64 percent of the initial value, but core forest habitat has been reduced to only 25/81 = approximately 31 percent of the prior area. Additionally, for species with limited mobility and ability to disperse, these easements might form barriers that isolate the patches and their populations.

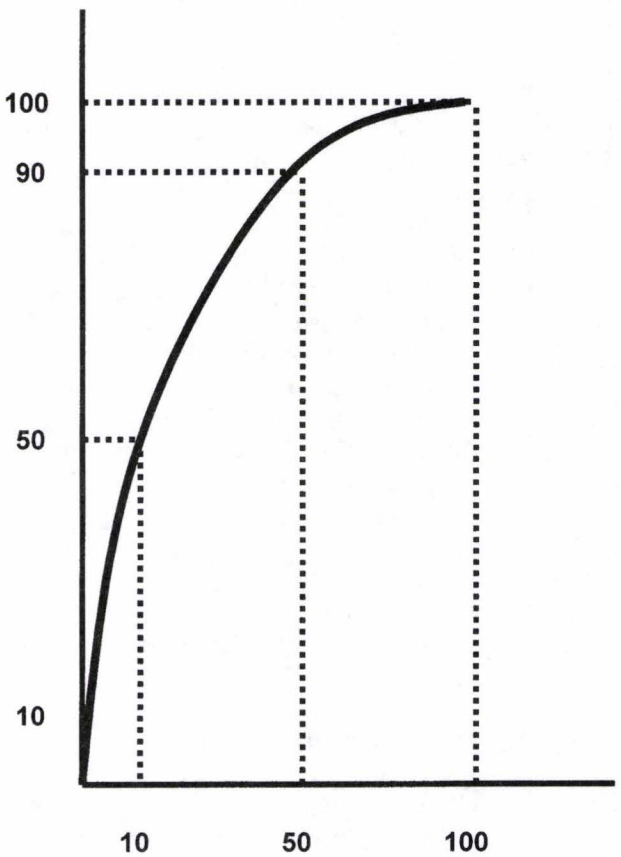

Figure 3.5—*The impact of reducing the size of the habitat island on the species richness supported by the island (modified from Primack 1998).*

Edge effects may be felt a great distance into a forest, far beyond the point where humans might sense them (Saunders *et al.* 1991). As a result, patch shape becomes important. Suppose that the square kilometer of forest discussed above were arranged in a patch 200 m wide by 5,000 m long, This would produce the same 1,000,000 m^2 (100 ha) of forest, but with absolutely no core habitat. To succeed as forest habitat, then, fragments must not only be large, but also must have a shape such that edge effects do not consume all, or even a high proportion, of the habitat core.

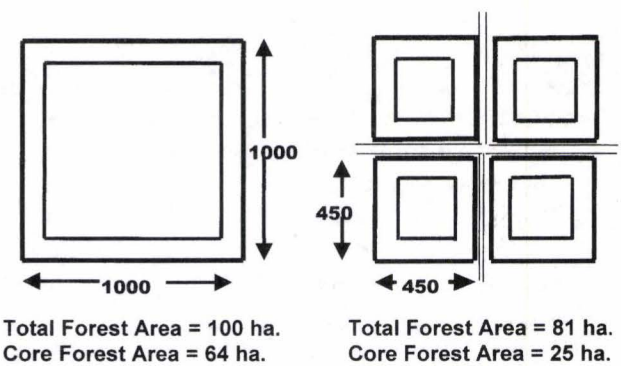

Figure 3.6—*The impact of fragmentation of a one square kilometer habitat patch by two perpendicular 100-m-wide road easements bisecting the patch with an edge effect of 100 m (modified from Primack 1998).*

Habitat edges often contain high species richness because they provide at least temporary habitat for species from the two contiguous habitat types, to which edge specialists might be added. As a result, it might superficially appear that promoting edge is beneficial to biodiversity. Although this may be the case as far as the immediate alpha diversity is concerned, reducing a large landscape to similar edge will produce a zone where beta diversity drops, since it will be devoid of core species; regional gamma diversity will therefore drop to the level of alpha diversity recorded at any one location.

This suggests a serious concern—and illusion—in the discussion of diversity. If we manage to maximize local alpha diversity in one habitat, we are not necessarily enhancing landscape or regional gamma diversity. Many of the species that the public favors for hunting are common edge dwellers, thus increasing edge seems to have benefits for those species. If we are to manage ecosystems for regional biodiversity, however, we must manage on the broad landscape level of gamma diversity by conserving all habitats; focusing on the narrow habitat or stand level where only alpha diversity is seen will not be helpful. By attempting to conserve in frequency and proportion the full array of habitats in the forest ecosystem in their historic pre-European patterns, we will be more likely to conserve the species richness, biodiversity, and health of the system.

In Missouri and elsewhere in the Midwest, habitat fragmentation and edge effects have caused concern especially with regard to populations of neotropical migrant songbirds, which have declined by as much as 50 percent in recent decades (Robinson *et al.* 1995, Faaborg *et al.* 1998). The decline in nesting success has been most precipitous in areas of greatest fragmentation—agricultural regions in the central and northern parts of the state—where populations of the brown-headed cowbird have simultaneously increased in population and range. The cowbirds, which feed in open agricultural areas, penetrate a few hundred yards into the forest to parasitize songbirds by laying their eggs in songbird nests, inhibiting reproduction in most farm woodlots. This phenomenon has now focused attention on the larger areas of contiguous forest in the Ozarks where forest interior birds have had higher nest success, areas that appear critical as reproductive source areas for dispersal of songbirds to more fragmented landscapes hundreds of miles distant. Through the Missouri Ozark Forest Ecosystem Project (Brookshire and Shifley 1997), scientists are now engaged in a long-term study of the effect of fragmentation and edge produced by even- and uneven-aged timber management on nesting success of neotropical migrants and on numerous other floral and faunal ecosystem attributes as well.

The problem of fragmentation in Missouri is further exacerbated by the pattern of landownership. Since only a limited proportion of forested land is publicly owned, solutions to forest management problems must involve the private landowner at least as much as the public land manager, especially where patches of public land are relatively small and noncontiguous. The boundary of the Mark Twain National Forest, for example, encompasses some 3 million acres, but some 50 percent of this is small private inholdings (Parker 1993). In a state with 83 percent of forested acres in private ownership, there are more than 300,000 private owners, almost 80 percent with tracts less than 50 acres in size (although these owners of the smallest tracts control only 22 percent of private acres). Many of these landowners are not interested in the commercial value of their trees, but manage—to the extent that they apply any active management—for other values and to meet other objectives (Jenkins and Smith 1999). Among those interested in the commercial value of the timber, Parker (1993) suggests that in the Central Hardwood Forest much of the private land is poorly managed or even mined because of high stumpage prices, with little concern being displayed for regeneration or ecosystem sustainability. One significant result of the fragmented pattern in forest ownership is the admonition of Franklin (1989) that "neither the current system of forest reserves, nor any conceivable such system, will be sufficient to provide adequate protection of biodiversity in the wide range of forest habitats."

Biodiversity: Role and Trends

Even if we view forests merely as a source of timber and other commodities, we should value the species richness forests contain for a number of reasons (modified from Johnson and Ditz 1997):

- The nutrient cycles in forests upon which productivity depends are driven by the complex and poorly understood interactions among soil microfauna.
- Biodiversity both influences and is influenced by soil fertility and productivity (Tillman *et al.* 1996, Karieva 1996).
- While community composition seems to be important in influencing the temporal stability of populations, primary productivity, nutrient dynamics, and invasibility by exotic (non-native) species, it is difficult to separate composition from biodiversity.
- Because the roles played by the various species in a community may not be substitutable and we don't know which species are critical, the loss of any species poses a potential threat.
- Since there are over 100,000 described species (and many additional undescribed species) in the U.S., this Nation is home to more species than most tropical countries. Furthermore, our forests may be home to 50 percent of these species.
- Biodiversity is the raw material for much of the agronomy, pharmacology, and biotechnology industries.
- Although trite, it is true that extinction is forever.

As Wilson (1993) pointed out, although our knowledge is still poor, enough is known that we can conclude that "biodiversity is vital to healthy forests, while proper forest management is vital to the maintenance of biodiversity." Predicting this judgment, conservation pioneer Aldo Leopold (1949) argued long ago that the wise tinker guards all the components.

Biodiversity at all levels (habitat, species, genetic) is declining in U.S. forests while old growth has virtually disappeared outside Alaska. This provides a troubling indicator of the ability of our forests to meet our long-term needs (Sample *et al.* 1993, Reid and Dower 1997). On the list of the top 10 U.S. regions with the most endangered species, four are forested areas. The Nature Conservancy studied 20,500 species, most of which live on or near forested habitats. The TNC report suggested that 2.5 percent are extinct or haven't been seen for decades, one-third are at risk, and nearly half have been reduced to fewer than 20 populations. The reported causes for these threats to biodiversity were not only logging but also development (TNC 1996). In the last 100 years, we have documented the extinction of 100 species and suspect that another 450 have similarly suffered. Not surprisingly, therefore, some 50 percent of the rare and endangered species of the U.S. are forest dwellers (Johnson and Ditz 1997). This pattern is little different in Missouri where over 25 percent of the animal species of conservation concern are forest dwellers (MDC 1999).

The leading causes of loss of species are habitat destruction, fragmentation, overharvesting, introduced species, disease, poorly enforced conservation/resource management laws, and the conversion of forest ecosystems to plantations (Johnson and Ditz 1997). Plantations are particularly favored by the pulp and paper industry because their equipment can deal better with the standardized fiber and predictable supply produced from such a source (Jenkins and Smith 1999). Although supporters argue that plantations can alleviate pressures on natural forests, this has yet to be demonstrated. While plantations are preferable to degraded environments with exposed and eroding soil, they lack the multilayered canopy, diversity in tree size, and abundant snags present in old-growth forests (Sharitz *et al.* 1992).

As long ago as the 1950s, concern was being expressed that sustained timber yield might be incompatible with maintaining fish, wildlife, and other non-timber forest products and services (Lyden *et al.* 1990). But we have succeeded at promoting populations of game species such as wild turkey and white-tailed deer and some predator species such as coyotes and bald eagles. This suggests that we are capable of promoting the interests of wildlife if land managers see a value in doing so. Sharitz *et al.* (1992) identified a number of techniques for promoting diversity including longer rotations, less intensive harvesting and site preparation, and retention of mature trees and snags during and following harvest. As has been noted, the conservation of beta diversity requires maintaining a variety of successional stages with an abundance of forest in mature and late stages. Abundant small patches may appear diverse, but mature and old-growth fragments must be large enough to support viable populations of species. Maintaining a relatively large proportion of a forest in old-growth is an essential component of a

strategy designed to maintain global diversity at risk.

Furthermore, as Johnson and Ditz (1997) noted, a sustainable forest will be one that can respond to disturbance and change. Since the ability of a forest to respond to such disturbances is vested in its genetic diversity, forest techniques that tend to simplify the system genetically threaten sustainability. Forestry that eliminates or promotes certain genotypes in a system at the expense of genetic variability is such a threat. Plantations are classic examples of genetic simplification.

In planning for maintenance of biodiversity, it is important to remember that the presence of a species in a habitat does not necessarily indicate population viability in that habitat. Many species exhibit a metapopulation structure with an array of populations of different sizes scattered across a broad geographic area. In such a landscape, some habitats will actually support successful viable breeding populations and export individuals, while other habitats may not promote breeding success and only support the reproductive excess from source areas. The latter habitats thus act as non-viable population sinks (Meffe and Carroll 1997). It is critical to identify and protect the source habitats.

If we are to acknowledge that the principle of ecological sustainability should guide forest management policies, programs, and techniques in Missouri, we must develop and adopt forestry policies and management techniques geared towards conserving the biodiversity of the forest ecosystem. We must not simply manage, as we do now, to preserve critically threatened and endangered species. Rather, if we recognize that biodiversity is a crucial component of a healthy forest, we will manage to prevent species becoming rare or endangered. This will require a much more comprehensive approach to forest planning and management at the landscape or regional level, dealing with ecosystems rather than the more traditional focus on individual stands. This in turn will necessitate interagency and public/private cooperation; we are reminded of the Coordinated Resource Management planning process that the Missouri Department of Conservation so hopefully initiated in 1994 in cooperation with other Federal and State agencies and willing private landowners but then prematurely rejected.

Managing for conservation of biodiversity will also tend to enhance other non-commodity benefits of forests. Such benefits, usually falling under the umbrella concept of ecosystem services, include watershed protection, maintenance of water yield and quality, recreational opportunities, open space, and esthetic values. These values now compete with timber as critical management objectives for forest systems, and indeed there is evidence that they contribute more in dollar value to gross domestic product than does timber harvest. And the greatest increase in recreational demand, in Missouri as in other states, is for non-consumptive activities such as wild-life viewing, hiking, and photography, all of which may be enhanced by the conservation of biodiversity.

POLICY IMPLICATIONS

The foregoing discussion of the components of ecologically sustainable forestry has implications for forest policy. Kohm and Franklin (1997) offer some broad advice to forest managers of the future. They suggest that "if 20th century forestry was about simplifying systems, producing wood, and managing at the stand level, 21st century forestry will be defined by understanding and managing complexity, providing a wide range of ecological goods and services, and managing across broad landscapes—managing for wholeness rather than the efficiency of individual components."

A number of authors have offered suggestions regarding those trends in forest management that could be used to assess whether or not we are moving towards sustainable forest management (Noss 1993, Johnson and Ditz 1997, Abramowitz 1998a, USDA 1999). While most recommendations address measurable trends in the forest itself, some also address trends in wood processing, and yet others deal with trends in the marketplace. We have combined the more critical ideas and offer the following set of 25 preferred trends in forest management and forest products management. If followed, these represent directions that collectively would lead towards sustainable forest management. We can use these preferred trends to assess whether or not Missouri is genuinely moving towards sustainable forest management. Furthermore, by judging the influence of specific policy proposals on these trends, we can also assess whether the policies are likely to have a positive or negative impact on forest sustainability.

In the forest, sustainable management will

1. While managing for the social, economic, and ecological needs of current and future generations, recognize that these include non-timber goods and ecological services.
2. Evaluate forest quality on a landscape rather than a stand level, and attempt not just to maintain quality, but also to enhance it.
3. Reverse the trend towards isolated forest fragments and towards excessive road construction while increasing the area of natural forest.
4. Decrease the proportion of an ecoregion in plantations while increasing the species and genetic diversity of those plantations remaining.
5. Institute harvesting practices that emulate the longer natural cycle of events, rather than the short rotation period that emphasizes early-successional stages. This will reverse the trend towards younger forests and increase the proportion of an ecoregion in mature to late-successional stages while increasing the carbon storage in trees and forests.
6. Manage in ways that mirror the heterogeneous conditions in natural forests, with many species, age classes, and sizes, thereby reversing the trend toward forest simplification.
7. Manage to enable or mimic natural disturbances. In particular, the trend toward elimination of fire should be reversed.
8. Decrease sedimentation loading in streams and rivers.
9. Increase the number of trees in urban and agricultural areas.
10. Attempt to increase the productivity of timber species, reducing the ratio of net timber harvest to net annual growth.
11. Accord special consideration to the protection of sensitive areas and important habitat, thereby reversing the trend towards an increasing number of threatened and endangered species.
12. Given the interdependence of species, maintain some organisms that were once considered pests (fungi and insects, for example) because they are essential to maintaining healthy ecosystem function.

During processing, sustainable management will

13. Reduce the production, use, and release of persistent toxins.
14. Reduce fossil fuel use throughout the forest products cycle.
15. Increase efficiency in the use of virgin tree fiber.
16. Increase the rate of paper and wood product recycling.
17. Where possible, increase the use of non-wood (agricultural plant) fiber instead of wood products (this applies only where such crops are grown on land already deforested, and is not meant to imply that forests should be cleared for alternative fiber sources to be cultivated in place of managed forests).

In the policy arena and the marketplace, sustainable management will

18. Allow all stakeholders, particularly local communities, to participate in developing management policies and decisions.
19. Increase the public disclosure of environmental performance in timber harvest, wood processing, and marketing.
20. Reduce overconsumption and waste of forest products, while promoting equity in public access to consumption.
21. Reform state and national policies and international agreements, such that sustainable forest management is promoted and unsustainable forest management is discouraged.
22. Enhance the markets of non-timber forest products and services.
23. Increase opportunities for recreation in forested environments.
24. Increase jobs and wages in forest communities.
25. Increase public-private partnerships to meet the goal of sustainable management.

The list of indicators within the seven criteria of sustainability itemized in the Montreal Process for the Conservation and Sustainable Management of Temperate and Boreal Forests (USDA 1999) comprises a very similar set of assessments, although the focus is on the forests themselves and pays no attention to wood processing and marketplace issues.

Johnson and Ditz (1997) also recommend a series of agency, institutional, and government policy steps that should be taken to promote such trends:

- Regional or state plans to promote sustainable management in the forest sector should be developed and implemented.
- A national network of sustainable forests should be established for demonstration purposes.
- Tax reforms should be developed that slow the pace of forest fragmentation and encourage larger forested tracts.
- Innovative financing schemes should be developed that promote restoration and enhancement of timber productivity on degraded lands.
- Through targeted incentive programs, land acquisitions, and land swaps, critically endangered forest ecosystems should be restored and protected.
- Incentive programs should seek to encourage carbon sequestering in U.S. forests, increase sustainable fiber supplies, and enhance rural development.
- Policies and programs should be deveoped that open the environmental performance of forestry companies and the forest products industry to public scrutiny.
- Policies and programs should be developed that promote the integration of sustainability into the goals, planning, and operations of corporations.
- A more robust sense of the concept of sustainability should be incorporated into U.S. forestry education programs.
- U.S. international leadership should be encouraged to promote sustainable forest management practices worldwide.

Certification of Sustainable Forest Products

As a result of pressures from environmentalists and consumers and the concern of its leaders for long-term resource availability, the forest products industry is beginning to respond to environmental concerns (Jenkins and Smith 1999). Not only is it inevitable that forestry will become sustainable, but many consumers are already demanding sustainable forestry by seeking the products of ecologically sustainable management. It is therefore reasonable that there should be an entity, independent of the producers, that serves to certify the sustainability of forest management procedures and forest products.

In 1993, the Forest Stewardship Council (FSC), based in Oaxaca, Mexico, was established to perform exactly such a role. The FSC has a set of guidelines that forest managers must follow to be certified. According to the FSC (1996) and Johnson and Ditz (1997), managers must

- Comply with laws and FSC principles
- Clearly define, document, and legally establish long-term tenure and use rights to the land
- Recognize and respect the legal rights of indigenous peoples to own, use, and manage their lands, territories, and resources
- Apply management operations that maintain or enhance the long-term social and economic well-being of forest workers and local communities
- Apply management operations that encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits
- Manage to conserve biodiversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and by so doing maintain ecological functions and the integrity of the forest
- Write, and keep current, a management plan appropriate to the scale and intensity of the operation that identifies the long-term objectives for the forest and means of achieving them
- Conduct monitoring appropriate to the scale and intensity of forest management that assesses the condition of the forest, yield of forest products, chain of custody, management activities, and their social and environmental impacts

- Conserve primary forest, well-developed secondary forest, and sites of major environmental, social, and cultural significance that will not be replaced by plantations or other land use following harvest
- Utilize plantations that reduce pressures on natural forests and thus complement, not replace, natural forests.

Companies independently certified as abiding by these guidelines do so because their customers expect it and because they believe that it makes good business sense. In 1996, less than 3 percent of internationally traded wood was certified although this was double the amount in 1994. By the end of 1998, it was expected that 10 million hectares of managed forest would be receiving FSC approval, while the World Bank and the World Wildlife Fund have committed to achieving 200 million such hectares by 2005 (Jenkins and Smith 1999). Worldwide demand for certified wood even now exceeds supply, so there is abundant room for growth in the commodity (Johnson and Ditz 1997). The demand for ecologically sustainable wood products seems to be greater in Europe than in North America, but North American demand is growing.

The challenge of promoting sustainable management has also been taken up by the American Forest and Paper Association. The AF&PA developed its own Sustainable Forestry Initiative (SFI), based on the principle that "AF&PA members are committed to ensuring that future generations of Americans will have the same abundant forests that we enjoy today. We will conduct all aspects of our business in an environmentally sensitive manner. We are convinced that sound environmental policy and sound business practice go hand in hand. We will pursue both for the benefit of our customers, shareholders, and the American people" (AF&PA 1996). Some 200 forest products companies have agreed to comply with the bylaw requirements for the SFI, suggesting that the forest products industry takes seriously concerns about sustainable management.

Although certification is no panacea, no substitute for reducing wasteful consumption or for sound forest management policies, it does provide a voluntary market-based approach to fostering sustainable forest management and trade. Even though development of the SFI program is being reviewed by an external panel (Hansen undated) and AF&PA memberships have been terminated for non-compliance with the guidelines, assessment of compliance seems to be undertaken through self-reporting and by the AF&PA itself. Unlike the Forest Stewardship Council, the AF&PA SFI certification process is not, therefore, completely independent.

The proposal to increase the area globally under certifiable sustainable management to 200 million hectares by 2005 has been endorsed by environmental and business groups as well as the World Bank (Abramovitz 1998a). Meanwhile, on a practical note, Van Putten (1999) extolled the virtues of certification when he announced that the National Wildlife Federation had started publishing its journal on the first certified paper produced in the U.S. The trend towards sustainability through certification is underway.

CONCLUSION

There will always be a need for forest products, but we can ensure that our needs for forest resources and services are met by forging a new relationship with forests: one that ensures conservation, sustainability of the forest resource, and the fair and equitable sharing of benefits. There may well be costs to be borne by everyone, from landowner to consumer, as we shift to sustainable management. The costs of not shifting to sustainability, however, will be higher and potentially irreversible.

One theme that has recurred throughout the writing on sustainability is the need for interdisciplinary, interagency cooperation and broad-based participatory planning. Given the tremendous importance of private forests in the overall scheme of planning and managing our forest resources, it will become essential that non-timber values are clearly seen to be reflected in management. Should this not occur, the pressure from conservationists and a concerned public to take public forests completely out of the timber base will only increase. And this in turn will increase the pressure on private lands.

Chief among the barriers to sustainability is the "growth myth" (Meffe and Carroll 1997), a view based upon the illusion that growth can continue indefinitely. We need to recognize that the environment, with its natural resources and ecosystem processes, is the

basis for all life, but the ability of our natural resources to support human consumption is limited. Sustainable management of natural resources is ultimately inevitable. If we fail to live responsibly off the interest provided by forest capital, sustainability might arrive when we have greatly reduced forest capital and thus reduced annual consumption. Disruption will be less severe if we acknowledge this and plan ways of adjusting management to achieve sustainability before it is forced upon us. Sustainability is not for some minority special interest sector of today's population. It is a global concern for future generations, and in perpetuity.

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Missouri's Timber Resources: Finding a Sustainable Balance Among Growth, Harvest, and Consumption

Stephen R. Shifley[1]

Abstract.—Missouri's 14 million acres of forest land cover nearly one-third of the state. The greatest concentrations of forest land and timber volume occur in the Ozark Highlands. Eighty-five percent of Missouri timberland is privately owned. Eighty percent of the private forest land acreage is in tracts between 20 and 500 acres in size. The standing volume of growing stock in Missouri is approximately 9 billion cubic feet. Non-growing-stock trees (rough and rotten) contain an additional 5 billion cubic feet of volume. Oak forest types predominate throughout the state. Between 1972 and 1989, annual growth of growing stock averaged 267 million cubic feet. Removals of growing stock over the same period averaged 117 million cubic feet. The net increase in growing-stock volume between 1972 and 1989 was 3 billion cubic feet. Missouri's 2,800 wood processing facilities produced 140 million cubic feet of forest products in 1997. That same year the 5 million people living in Missouri consumed 400 million cubic feet of wood products. Thus, consumption of wood products in the State that year far exceeded both growth and harvest, and Missouri was a net importer of wood products. It is widely acknowledged that with better management Missouri's forests could produce substantially more wood than they currently do. This raises a number of interesting questions about the quantity of wood Missouri forests *could* produce relative to levels of consumption and about the local and global ramifications of producing more wood locally.

Assessing forest sustainability requires consideration of many factors: forest growth, timber harvest, wildlife of all types, water quality, social values, biodiversity, disturbance rates, and forest pests. Consequently, inventories of forest vegetation and timber production are never fully sufficient to determine forest sustainability (or its lack). However, forest vegetation inventories are always a good starting point for understanding the current state of forest resources, future opportunities, and issues of concern. The condition of forest vegetation is the focus of many of the global indicators of sustainable forest management (USDA Forest Service 1997, Canadian Council of Forest Ministers 1997). The periodic surveys of forest vegetation and timber production provide important quantitative indicators of forest conditions and the changes in those conditions over time. Forest statistics for Missouri have been maintained for more than a century, and over that time the measurements have increased in detail, statistical rigor, and public accessibility.

Current forest conditions, rates of growth, and rates of harvest are usually measured concurrently during periodic forest inventories (e.g., Spencer *et al.* 1992, Powell *et al.* 1994). However, it is rare to simultaneously consider the demands placed on forest resources through consumption of wood products. Assessing sustainability in the broad sense requires us to jointly consider forest growth, forest harvesting, and forest product consumption. In the face of stable or increasing consumption of forest products, a decrease in timber harvest locally simply increases the harvest elsewhere—often in another state or

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another nation. Shifting timber harvests to another locale may actually decrease global sustainability if the harvests occur at locations where poor management practices are tolerated. Consequently, we cannot discuss forest sustainability without considering what demands we create for forest products (locally and globally) and *how* and *where* those demands will be met with wood products or substitutes.

This paper provides an overview of forest conditions in Missouri with special emphasis on trees, timber product outputs, and consumption of timber products. It includes recent trends in forest growth and removals, and it places Missouri's current situation in the context of the United States as a whole. The current condition of Missouri's forest resources offers both challenges and opportunities, and several of these are discussed in later sections.

METHODS AND DATA

The data summarized in this paper came from four principal sources. First, information about current forest area, volume, species composition, age, size, growth, mortality, and removals was derived from the 1989 field inventory of approximately 4,000 sample plots systematically distributed across all forest land in Missouri. Methods and inventory results were reported in Spencer *et al.* (1992), and Hahn and Spencer (1991) and were supplemented by earlier inventories of Missouri (USDA Forest Service 1948, Gansner 1965, Spencer and Essex 1976). Additional summaries were generated using an online database including the raw data and associated software for custom database query (Hansen *et al.* 1992). Estimates of timber removals were combined with a second source of information, periodic surveys of the wood using industries in Missouri. The most recent survey of Missouri forest industries was conducted in 1997 (Piva *et al.* 2000). Earlier surveys based on this methodology date back to 1946 (King *et al.* 1949, Little 1949, McGinnes 1965, Blyth and Massengale 1972, Blyth *et al.* 1983, Smith and Jones 1990, Hackett *et al.* 1993, Piva and Jones 1997), and recent data are available through an online database (May 1998). Estimates of consumption of forest products since 1965 came from periodic Forest Service reports (Howard 1999). A fourth source of information was maps of land cover that were previously classified based on satellite imagery (USDA Forest Service 1993).

FOREST AREA AND OWNERSHIP

Missouri has 14 million acres of forest land; this is 30 percent of the State's 44 million acres (see forest cover map on cover). The forest land in Missouri is concentrated in the southeastern portion of the Ozark Highlands. Two-thirds of the Eastern Ozark region is forested, although only one-eighth of northern Missouri is forested (Hahn and Spencer 1991). Ninety-six percent of Missouri's forested acres (13.4 million acres) are biologically capable of producing commercial crops of trees and are classified as timberland (i.e., capable of annually producing at least 20 cubic feet of wood per acre and not withdrawn from timber production by statute or administrative policy). The remaining forest land (approximately 600,000 acres in total) is equally divided among lands that are withdrawn from timber production and lands that are on poor sites incapable of producing commercial crops of timber.

Missouri is divided into five inventory regions (inventory units) based on broad similarities in geology, landforms, and forest vegetation (fig. 4.1) (Spencer *et al.* 1992). These regions were established in the 1940s to assist in sampling and reporting forest statistics for subregions of the state, and they have been used in all subsequent state inventories. Today, data are also reported by counties and can be summarized for other geographic regions (Hahn and Spencer 1991, Spencer *et al.* 1992, Hansen *et al.* 1992, http://www.srsfia.usfs.msstate.edu/scripts/ew.htm). Within the five Missouri inventory regions, the proportion of timberland ranges from 13 percent in the Prairie Region to 67 percent in the Eastern Ozarks. Nearly two-thirds of Missouri's timber volume is in the southern half of the state within the three Ozark inventory regions. Fully one-third of Missouri's total timber volume lies in the Eastern Ozarks region.

Although the greatest total volume of timber is found in the Ozarks, some of Missouri's most productive timberland per acre is found in the Prairie and Riverborder regions. Most of the rich soils in the river bottoms have been cleared for agriculture, but the forests that remain have greater volumes on average than other regions of the state. A variety of factors

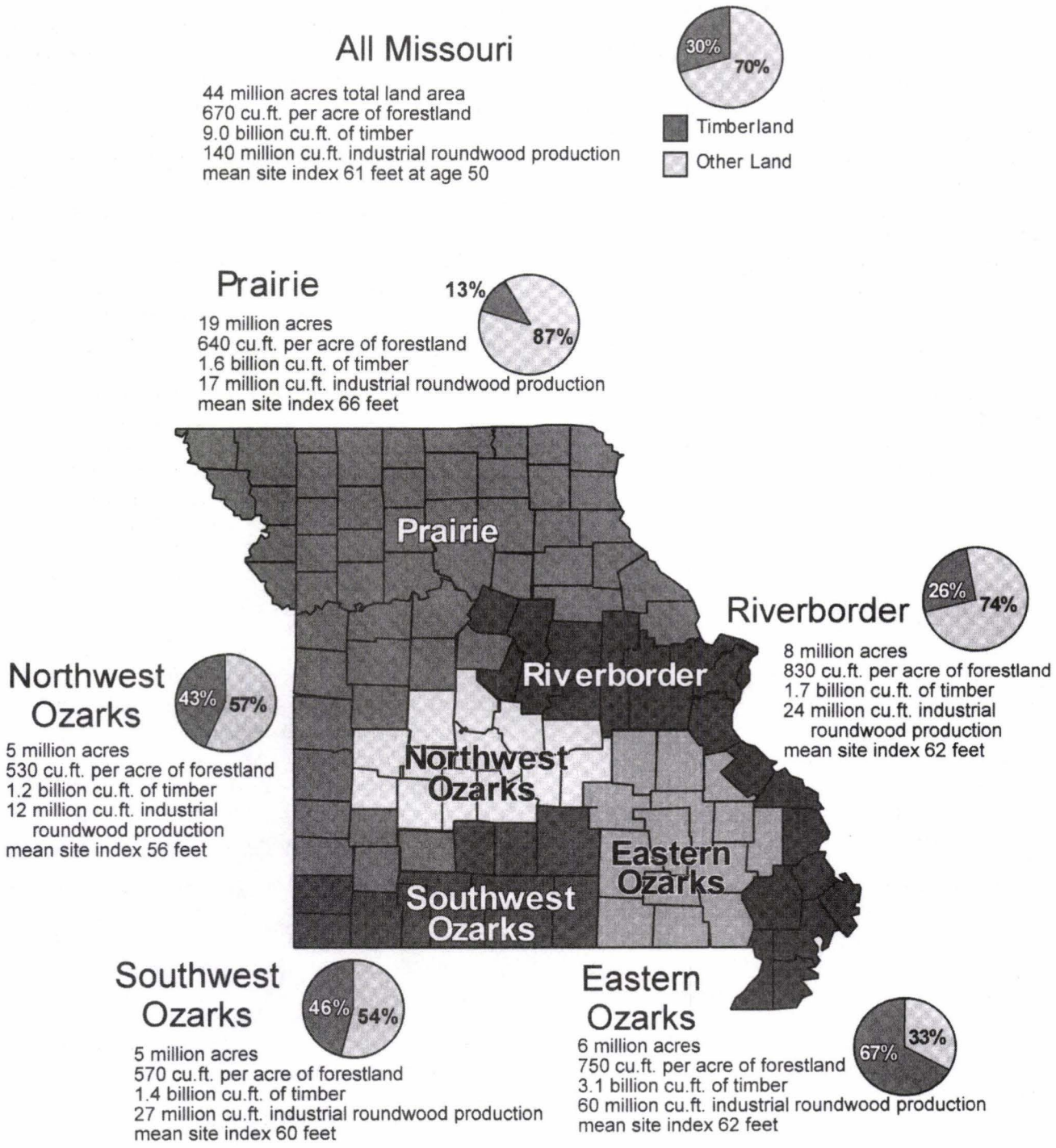

Figure 4.1—*Missouri inventory regions showing percent forest cover, standing volume, mean volume per acre, and mean site index, 1989. (From Hahn and Spencer 1991, Piva* et al. *2000, Hansen* et al. *1992, and http://www.srsfia.usfs.msstate.edu/scripts/ew.htm).*

such as cutting history and past disturbances can affect the mean volume per acre in a region. Site index is an estimate of the height that trees on a site can reach by age 50 years if they are undisturbed and free to grow. Thus, site index is a relative indicator of potential forest productivity. Regional rankings of timberland site quality based on site index are Prairie (mean site index 66 feet) > Riverborder (62) = Eastern Ozarks (62) > Southwest Ozarks (60) > Northwest Ozarks (56). These site index values include only areas that remain in timberland. Many of the most productive sites in the Prairie, Riverborder, and other regions have been converted to agriculture.

The majority of Missouri's timberland is owned by private individuals. Approximately 303,000 private individuals control 76 percent of the timberland in Missouri (Hahn and Spencer 1991, Birch 1996). Another 7 percent of timberland is in non-industrial corporate ownership. Forest industries own an additional 2 percent for a total combined private timberland ownership of 85 percent. The Mark Twain National Forest includes 10 percent of the State's timberland, the State of Missouri owns 3 percent, and the remaining 2 percent is in other public holdings.

Most private forest landowners in Missouri own small tracts of timber. Inferences about private landowners and their attitudes are heavily dependent upon whether the focus is on the number of owners or the number of forest land acres they control. In Missouri, 64 percent of the owners have tracts smaller than 20 acres in size, and collectively that group of owners controls only 9 percent of the State's private forest land. Based on tract acreage, 80 percent of total private forest acres are in ownerships between 20 and 500 acres in size (Birch 1996). The mean length of ownership of a private forest land acre in Missouri is 28 years. Forty-two percent of private forest landowners in the state have harvested timber in the past, and this group controls three-fourths of the private forest land acreage. Thirty-eight percent of owners who control 59 percent of the forest land indicated in 1993 that they intended to harvest timber within the next 10 years.

SPECIES, AGE, AND SIZE CLASS

The most recent inventory of Missouri (Hahn and Spencer 1991, Spencer *et al.* 1992) identified 88 tree species (table 4.1). Three species—white oak, black oak, and post oak—account for half of the standing volume and 29 percent of all trees in the state. Ten species make up 72 percent of the standing volume (a measure of size and dominance). However, based on the number of trees (a measure of abundance rather than size), flowering dogwood, American elm, blackjack oak, and three hickories move into the top 10 slots, indicating that those species are abundant but small in size relative to species with greater total volume.

Forests are often classified by forest type. Forest types are groups of species that commonly occur together due to similar disturbance histories and similar local site conditions (e.g., moisture regime, soil characteristics, slope, and aspect). More than three-fourths of Missouri forests are oak types (fig. 4.2). In the heavily forested Eastern Ozark region, 90 percent of the forests are oak-dominated. On a statewide basis, the oak types are followed in total area by maple types (7 percent, predominatly in northern Missouri), elm-ash-soft maple (4 percent, predominantly riparian), and eastern redcedar-hardwood types (4 percent, predominantly old-field). Shortleaf pine and shortleaf pine-oak forests cover an additional 5 percent of timberland in southern Missouri.

The current age distribution of Missouri's timberland is a direct result of past patterns of disturbance, particularly harvest, fire, conversion to agriculture, and abandonment of cleared lands (see Flader, this volume). In 1989, Missouri's forests were dominated by acres in the 50-year age class (60-year age class as of this writing) (fig. 4.3).

VOLUME

The volume of timber in Missouri is vast. It totals 9 billion cubic feet of standing growing-stock timber (i.e., volume of live trees of commercial species from a 1-foot stump to a 4-inch top diameter outside bark, exclusive of rot or defect) (Hahn and Spencer 1991). It is hard to comprehend the magnitude of this quantity of wood. If these 9 billion cubic feet of wood were stacked end to end, they could circle the Earth 68 times. This total includes 26

Table 4.1—*Volume and abundance of the 88 tree species recorded during the 1989 Missouri inventory. Based on the eastwide forest inventory database (Hansen et al. 1992, http://www.srsfia.usfs.msstate.edu/scripts/ew.htm).*

Species	Volume			No. of trees		
	Total (thousand cubic feet)	Percent	Cumulative percent	Total (thousand trees)	Percent	Cumulative percent
White oak (*Quercus alba* L.)	2,922,693	21.2	21.2	779,035	10.6	10.6
Black oak (*Quercus velutina* Lam.)	2,505,912	18.1	39.3	701,239	9.5	20.1
Post oak (*Quercus stellata* Wangenh.)	1,572,353	11.4	50.7	660,405	9.0	29.1
Shortleaf pine (*Pinus echinata* Mill.)	637,576	4.6	55.3	162,549	2.2	31.3
Scarlet oak (*Quercus coccinea* Muenchh.)	605,309	4.4	59.7	154,916	2.1	33.4
Northern red oak (*Quercus rubra* L.)	575,822	4.2	63.9	88,635	1.2	34.6
Shagbark hickory (*Carya ovata* (Mill.) K. Koch)	315,020	2.3	66.1	183,371	2.5	37.1
Black walnut (*Juglans nigra* L.)	296,774	2.2	68.3	83,507	1.1	38.2
Blackjack oak (*Quercus marilandica* Muenchh.)	279,405	2.0	70.3	222,848	3.0	41.2
Eastern redcedar (*Juniperus virginiana* L.)	266,777	1.9	72.2	384,009	5.2	46.5
Mockernut hickory (*Carya tomentosa* (Poir.) Nutt.)	252,782	1.8	74.1	226,175	3.1	49.5
Pignut hickory (*Carya glabra* (Mill.) Sweet)	252,033	1.8	75.9	247,218	3.4	52.9
Black hickory (*Carya texana* Buckl.)	244,900	1.8	77.7	345,712	4.7	57.6
Sycamore (*Platanus occidentalis* L.)	230,034	1.7	79.3	23,757	0.3	57.9
Chinkapin oak (*Quercus muehlenbergii* Engelm.)	217,471	1.6	80.9	67,058	0.9	58.8
Silver maple (*Acer saccharinum* L.)	207,769	1.5	82.4	34,455	0.5	59.3
American elm (*Ulmus americana* L.)	201,973	1.5	83.9	364,804	5.0	64.2
White ash (*Fraxinus americana* L.)	189,915	1.4	85.3	153,635	2.1	66.3
Eastern cottonwood (*Populus deltoides* Bartr. ex Marsh.)	187,603	1.4	86.6	6,338	0.1	66.4
Hackberry (*Celtis occidentalis* L.)	156,729	1.1	87.8	114,550	1.6	68.0
Sugar maple (*Acer saccharum* Marsh.)	148,281	1.1	88.8	150,594	2.0	70.0
Shingle oak (*Quercus imbricaria* Michx.)	134,109	1.0	89.8	53,046	0.7	70.7
Honeylocust (*Gleditsia triacanthos* L.)	118,564	0.9	90.7	42,292	0.6	71.3
Pin oak (*Quercus palustris* Muenchh.)	117,981	0.9	91.5	20,757	0.3	71.6
Black willow (*Salix nigra* Marsh.)	116,002	0.8	92.4	16,169	0.2	71.8
Bitternut hickory (*Carya cordiformis* (Wangenh.) K. Koch)	105,822	0.8	93.1	84,427	1.2	72.9
Bur oak (*Quercus macrocarpa* Michx.)	88,487	0.6	93.8	12,351	0.2	73.1
Green ash (*Fraxinus pennsylvanica* Marsh.)	76,595	0.6	94.3	56,212	0.8	73.9
Swamp white oak (*Quercus bicolor* Willd.)	61,588	0.5	94.8	9,966	0.1	74.0
Blackgum (*Nyssa sylvatica* Marsh.)	59,220	0.4	95.2	121,284	1.7	75.7
Slippery elm (*Ulmus rubra* Mühl.)	57,679	0.4	95.6	175,221	2.4	78.0
Southern red oak (*Quercus falcata* Michx.)	55,385	0.4	96.0	14,019	0.2	78.2
Black cherry (*Prunus serotina* Ehrh.)	49,863	0.4	96.4	80,987	1.1	79.3
Osage-orange (*Maclura pomifera* (Raf.) Schneid.)	44,197	0.3	96.7	32,268	0.4	79.8
Boxelder (*Acer negundo* L.)	43,183	0.3	97.0	25,470	0.4	80.1
River birch (*Betula nigra* L.)	41,099	0.3	97.3	7,215	0.1	80.2
Shellbark Hickory (*Carya laciniosa* (Michx. f.) Loud)	32,768	0.2	97.5	10,828	0.2	80.4
Red mulberry (Morus rubra L.)	32,567	0.2	97.8	57,792	0.8	81.1
American basswood (*Tilia americana* L.)	29,530	0.2	98.0	9,561	0.1	81.3
Black locust (*Robinia pseudoacacia* L.)	28,882	0.2	98.2	10,454	0.1	81.4
Pecan (*Carya illinoensis* (Wangenh.) K. Koch)	24,825	0.2	98.4	4,847	0.1	81.5
Red maple (*Acer rubrum* L.)	22,988	0.2	98.5	97,536	1.3	82.8
Sassafras (*Sassafras albidum* (Nutt.) Nees)	18,694	0.1	98.7	219,727	3.0	85.8
Swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.)	17,596	0.1	98.8	7,824	0.1	85.9
Common persimmon (*Diospyros virginiana* L.)	14,693	0.1	98.9	102,543	1.4	87.3

(table continued on next page)

Species	Volume			No. of trees		
	Total (thousand cubic feet)	Percent	Cumulative percent	Total (thousand trees)	Percent	Cumulative percent
Eastern white pine (*Pinus strobus* L.)	13,845	0.1	99.0	1,678	< 0.1	87.3
Winged elm (*Ulmus alata* Michx.)	13,637	0.1	99.1	90,189	1.2	88.5
Flowering dogwood (*Cornus florida* L.)	11,656	0.1	99.2	527,439	7.2	95.7
Baldcypress (*Taxodium distichum* (L.) Rich.)	11,257	0.1	99.3	430	< 0.1	95.7
Eastern redbud (*Cercis canadensis* L.)	10,741	0.1	99.4	71,908	1.0	96.7
Shumard oak (*Quercus shumardii* Buckl.)	10,024	0.1	99.4	567	< 0.1	96.7
Sweetgum (*Liquidambar styraciflua* L.)	9,083	0.1	99.5	3,866	0.1	96.7
Overcup oak (*Quercus lyrata* Walt.)	8,685	0.1	99.6	1,639	< 0.1	96.8
Kentucky coffeetree (*Gymnocladus dioicus* (L.) K. Koch)	8,059	0.1	99.6	3,233	< 0.1	96.8
Rock elm (*Ulmus thomasii* Sarg.)	6,646	0.1	99.7	9,675	0.1	96.9
Swamp chestnut oak (*Quercus michauxii* Nutt.)	5,500	< 0.1	99.7	918	< 0.1	97.0
Blue ash (*Fraxinus quadrangulata* Michx.)	5,293	< 0.1	99.7	3,585	0.1	97.0
Ohio buckeye (*Aesculus glabra* Willd.)	5,199	< 0.1	99.8	11,569	0.2	97.2
Yellow-poplar (*Liriodendron tulipifera* L.)	4,445	< 0.1	99.8	1,308	< 0.1	97.2
Butternut (*Juglans cinerea* L.)	3,168	< 0.1	99.8	2,041	< 0.1	97.2
Cherrybark-Swamp red oak (*Quercus falcata* var. *pagodaefolia* Ell.)	3,118	< 0.1	99.9	527	< 0.1	97.2
White mulberry (*Morus alba* L.)	3,071	< 0.1	99.9	6,274	0.1	97.3
E. Hophornbeam- Ironwood (Ostrya virginiana (Mill.) K. Koch)	2,560	< 0.1	99.9	93,448	1.3	98.6
Willow Oak (Quercus phellos L.)	2,514	< 0.1	99.9	268	< 0.1	98.6
Virginia pine (*Pinus virginiana* Mill.)	1,897	< 0.1	99.9	423	< 0.1	98.6
American beech (*Fagus grandifolia* Ehrh.)	1,508	< 0.1	99.9	808	< 0.1	98.6
Unknown or not listed	1,462	< 0.1	99.9	23,254	0.3	98.9
Black maple (*Acer nigrum* Michx. f.)	1,283	< 0.1	100.0	296	< 0.1	98.9
Am. hornbeam-musclewood (*Carpinus caroliniana* Walt.)	1,174	< 0.1	100.0	15,688	0.2	99.1
Chittamwood-gum Bumelia (*Bumelia lanuginosa* (Michx.) Pers.)	1,130	< 0.1	100.0	9,128	0.1	99.2
Scotch pine (*Pinus sylvestris* L.)	577	< 0.1	100.0	303	< 0.1	99.2
Water tupelo (*Nyssa aquatica* L.)	509	< 0.1	100.0	110	< 0.1	99.2
Swamp cottonwood (*Populus heterophylla* L.)	393	< 0.1	100.0	31	< 0.1	99.2
Ailanthus (*Ailanthus altissima* (Mill.) Swingle)	374	< 0.1	100.0	301	< 0.1	99.3
Northern pin oak (*Quercus ellipsoidalis* E. J. Hill)	341	< 0.1	100.0	197	< 0.1	99.3
Peachleaf willow (*Salix amygdaloides* Anderss.)	321	< 0.1	100.0	326	< 0.1	99.3
Chestnut oak (*Quercus prinus* L.)	319	< 0.1	100.0	188	< 0.1	99.3
Hawthorn (*Crataegus* L.)	318	< 0.1	100.0	23,350	0.3	99.6
Sugarberry (*Celtis laevigata* Willd.)	309	< 0.1	100.0	728	< 0.1	99.6
Apple Sp. (*Malus* Mill.)	281	< 0.1	100.0	2,985	< 0.1	99.6
Waterlocust (*Gleditsia aquatica* Marsh.)	190	< 0.1	100.0	178	< 0.1	99.6
Water hickory (*Carya aquatica* (Michx. f.)Nutt.)	161	< 0.1	100.0	174	< 0.1	99.6
Wild plum (*Prunus americana* Marsh.)	157	< 0.1	100.0	10,901	0.2	99.8
Northern catalpa (*Catalpa speciosa* Warder)	107	< 0.1	100.0	498	< 0.1	99.8
Pawpaw (*Asimina triloba* (L.) Dunal)	71	< 0.1	100.0	14,408	0.2	100.0
Ozark chinkapin (*Castanea ozarkensis* Ashe)	70	< 0.1	100.0	190	< 0.1	100.0
Siberian elm (*Ulmus pumila* L.)	66	< 0.1	100.0	133	< 0.1	100.0
Chokecherry (*Prunus virginiana* L.)	0	< 0.1	100.0	1,203	< 0.1	100.0
Total	13,810,965	100.0	100.0	7,364,049	100.0	100.0

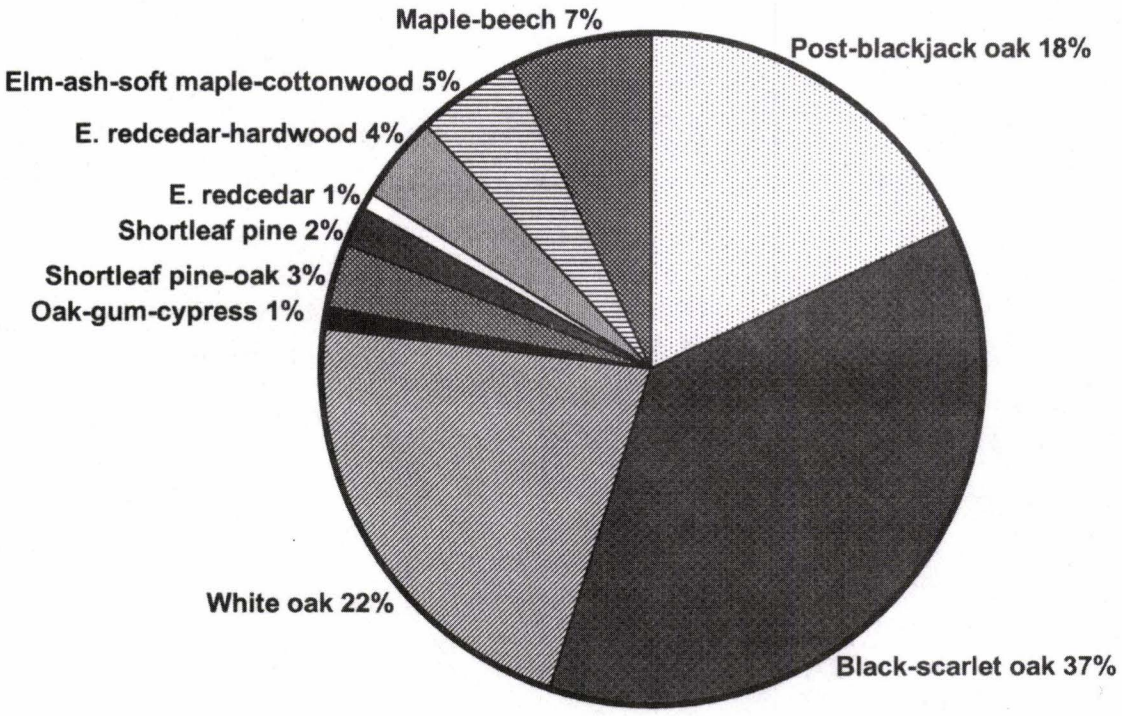

Figure 4.2—*Forest cover types in Missouri, 1989. Oak-dominated forest types cover 80 percent of Missouri timberland. (From Hahn and Spencer 1991).*

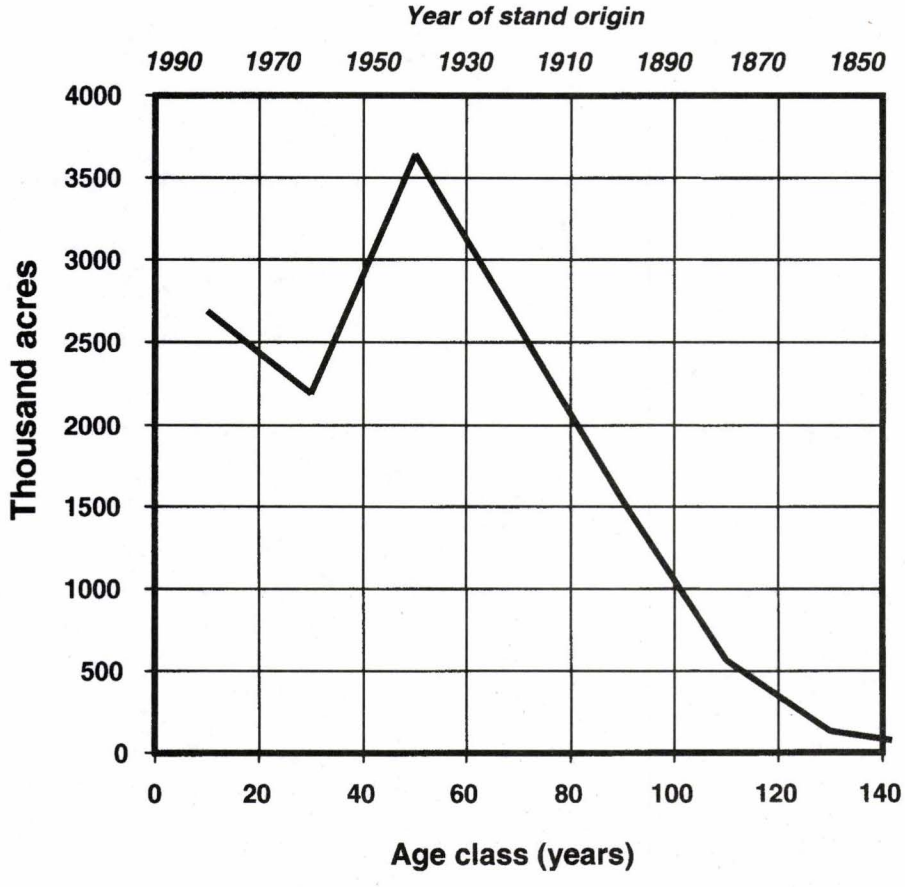

Figure 4.3—*Acres of forest by stand age class in Missouri, 1989. (From Hahn and Spencer 1991) .*

billion board feet of standing timber from sawtimber trees. A board foot is the equivalent of a piece of wood 12 inches by 12 inches by 1 inch from trees that (a) are a commercial species, (b) have a minimum breast height diameter of 9 inches for softwoods or 11 inches for hardwoods, and (c) contain at least one 12-foot saw log or two 8-foot saw logs. Note that minimum tree size requirements are different for inventories of board feet and cubic feet. The cubic foot volume of sawtimber trees is included in estimates of total cubic foot volume, but many trees with cubic foot volumes are too small to contain any board feet.

On average, volumes in Missouri are highest on national forest lands followed by State forests, industrial forests, other Federal forests, and forests owned by private individuals (table 4.2). County and municipal forest lands have the lowest volume per acre, but the mean age of county and municipal forest land is low relative to the other ownership groups (36 years vs. 48 to 53 years).

In addition to growing-stock trees, Missouri has a large volume of wood in trees that are classified as rough or rotten (Hahn and Spencer 1991). These trees do not meet the minimum standards for a growing-stock tree because they are not a commercial species, they have poor form (do not and/or will not contain at least one 12-foot saw log or two 8-foot saw logs), or they are rotten (at least half the volume is rotten). Collectively, the rough and rotten trees are sometimes referred to as cull trees because they are unsuitable for lumber production. However, many rough or rotten trees are still utilized for low value forest products such as blocking, pallets, fuelwood, or chips for paper production. In total the volume of rough and rotten (cull) trees is 4.9 billion cubic feet, an amount equivalent to half the volume of growing-stock trees. Of this amount, approximately one-sixth of the volume is in rotten trees, one-sixth is in short log trees (i.e., the subset of rough trees having one saw log between 8 and 11 feet in length), and the remaining two-thirds is in other types of rough trees including noncommercial species and trees with poor form.

By a wide margin, Missouri has a greater volume of rough and rotten (cull) trees than any other state in the Nation. Mississippi is a distant second in cull volume with 2.9 billion cubic feet. The total volume of rough and rotten cull trees in the United States is 56 billion cubic feet of which Missouri has nearly 9 percent. The disproportionately large volume in Missouri is the result of relatively low site quality and poor past forest management practices. The mean potential site productivity for an average acre of timberland in Missouri is lower than for any of the neighboring states.

Table 4.2—*Mean volume of growing-stock trees*[a] *per acre and total acres of timberland by owner group, Missouri 1989. Table entries are ordered by decreasing volume per acre. From Hahn and Spencer (1991) and the eastwide forest inventory database (Hansen* et al. *1992, http://www.srsfia.usfs.msstate.edu/scripts/ew.htm).*

Owner	Mean volume per acre		Acres (thousands)
	Cu ft[b]	Bd ft[c]	
National forest	871	2,538	1,321
State	786	2,463	403
Forest industry	776	2,200	222
Other Federal	676	2,081	246
Private landowners	641	1,829	11,137
County and municipal	526	1,387	42
All owners	671	1,928	13,371

[a] A growing-stock tree is a live timberland tree of commercial species that contains at least one 12-foot saw log or two saw logs 8 feet or longer, now or prospectively, and that meets specified standards of size, quality, and merchantability. (Note: excludes rough, rotten, and dead trees.)

[b] Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4.0-inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs.

[c] Net volume in board feet (i.e., the amount of lumber 1 foot long, 1 foot wide, and 1 inch thick or the equivalent) in growing-stock trees from stump to a minimum 7.0-inch top diameter outside bark (d.o.b.) for softwoods and a minimum 9.0-inch top d.o.b. for hardwoods that meet regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches d.b.h. Board feet are measured using the International ¼-inch rule.

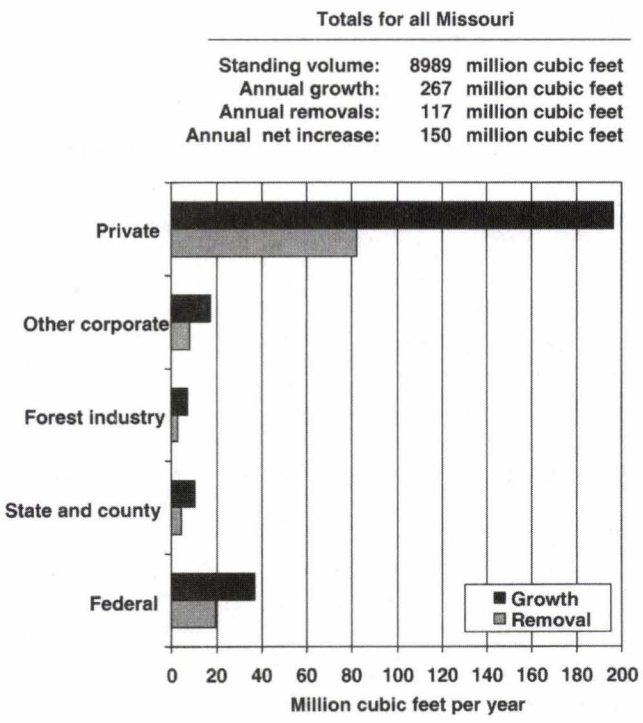
Totals for all Missouri
Standing volume: 8989 million cubic feet
Annual growth: 267 million cubic feet
Annual removals: 117 million cubic feet
Annual net increase: 150 million cubic feet
Private
Other corporate
Forest industry
State and county
Federal
Growth
Removal
0 20 40 60 80 100 120 140 160 180 200
Million cubic feet per year

Figure 4.4—*Mean annual growth and removals by owner group on timberland in Missouri, 1972-1989. Removals were 44 percent of growth. (From Hahn and Spencer 1991)*

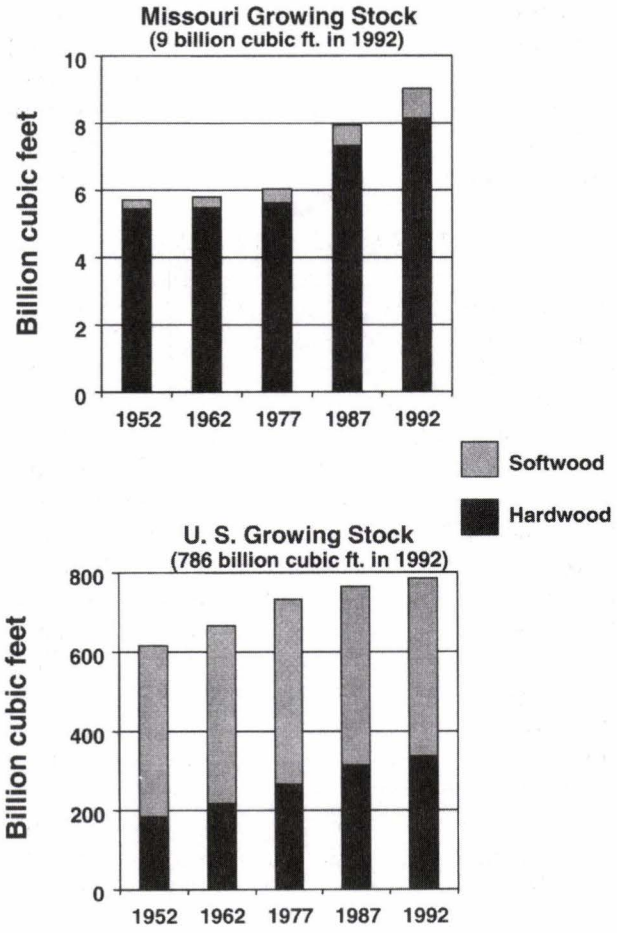

Figure 4.5—*Volume of growing stock in Missouri and the United States, 1952-1992. (From Powell* et al. *1994)*

GROWTH AND REMOVALS

Between 1972 and 1989, the average net annual growth in Missouri was 267 million cubic feet (including annual sawtimber growth of 1 billion board feet, International 1/4-inch scale) (Spencer *et al.* 1992). Annual growth was equivalent to approximately 3 percent of the standing inventory. Removals over the same period averaged 117 million cubic feet (including 0.4 billion board feet of sawtimber) annually or 1.5 percent of the standing inventory. Removals amounted to 44 percent of growth on a cubic foot basis. The annual net increase (growth less removals) over this period was 150 million cubic feet, and it was well distributed across all owner groups (fig. 4.4). Thus, the volume of timber increased from 6 to 9 billion cubic feet (including a sawtimber increase from 15 to 26 billion board feet) between 1972 and 1989, continuing a trend that dates back to the 1950s (fig. 4.5).

The extensive harvests and corresponding reductions in Missouri's timber resource between 1890 and 1910 and again in the late 1940s are well documented (Flader, this volume). Annual lumber production in Missouri peaked in about 1900 at more than 700 million board feet. Over the next 30 years, lumber production gradually fell below 300 million board feet as the best sites were harvested and abandoned. Many cutover areas were cleared, farmed, grazed, and periodically burned. Over time, as farms were abandoned and wildfires were controlled, the current generation of forest became established. Thus, between 1972 and 1989, a large number of forested acres were in size and age classes that had rapid increases in volume. Also, a substantial number of acres cleared for grazing in the 1960s were allowed to revert back to timberland. Missouri forests have rebounded from those periods of intense harvesting and land clearing. Over the past 50 years, the volume of timber in Missouri has increased steadily because annual growth has exceeded harvest. Trends for Missouri are consistent

with those for the United States as a whole; nationally timber volumes have also increased for the past 50 years (Powell *et al.* 1994). Forest growth in Missouri could be increased substantially by expanding the number of acres that are intensively managed for timber resources.

FOREST PRODUCTS

In 1997, Missouri had 458 primary wood-using mills (Piva *et al.* 2000) (table 4.3). The number of mills has decreased at each inventory since 1946 when more than 2,800 primary wood-using mills were located in the state. Between 1946 and 1980, production of wood products fell by 50 percent from 174 to 88 million cubic feet, but between 1980 and 1997, production increased to 140 million cubic feet (table 4.3). Products include saw logs, cooperage, veneer logs, charcoal, fence posts, handle bolts, and pulpwood. In 1997, saw logs accounted for 90 percent of the industrial roundwood production in Missouri (Piva *et al.* 2000). Cooperage and pulpwood follow at a distant second with 4 percent and 3 percent of the total, respectively. The recent addition of two chip mills in Missouri ensures increased pulpwood utilization in coming years.

Table 4.3—*Number of primary processing mills and volume of timber products produced in Missouri, 1946-1997. (From Piva* et al. *2000)*

Year	No. of mills	Roundwood production Million cu ft
1946	2,806	174
1958	1,161	136
1969	681	124
1980	599	88
1987	491	100
1991	471	121
1994	461	133
1997	458	140

Ninety-four percent of the wood processed in Missouri is from Missouri forests. The amount of wood imported from other states for processing is roughly equal to the amount exported for processing elsewhere. The majority of forest products are produced in the Ozarks where the majority of the standing volume is located (fig. 4.1). Production relative to the volume of timber in the Eastern Ozark and Southwest Ozark inventory units is greater than for the three other inventory units in the state.

About 18 percent of the wood utilized for products in Missouri comes from sources other than growing-stock trees. This includes rough and rotten trees (culls), dead trees, limbs, and trees from land that is not considered commercial forest. Trees from the red oak group (50 percent of total wood material used), the white oak groups (25 percent), shortleaf pine (6 percent), and cottonwood (5 percent) supply the majority of material harvested for wood products (Piva *et al.* 2000). Except for cottonwood, these are the most abundant commercial species in Missouri (table 4.1).

CONSUMPTION OF WOOD PRODUCTS

Consumption of timber products is the third component of forest sustainability that must be examined in conjunction with timber growth and removals. The average annual consumption of wood products in the U.S. is the equivalent of 74 cubic feet per person (1997 values) (Howard 1999). Per capita consumption varies annually, and between 1965 and 1997 ranged from 56 to 83 cubic feet. Between 1987 and 1997, per capita consumption gradually declined from 83 to 74 cubic feet, but due to increasing population levels, total U.S. consumption of timber products remained fairly steady. Lumber products constitute slightly less than half of annual consumption (fig. 4.6). The proportion of pulp-based products increased slightly over the last decade and now stands at nearly one-third of total consumption.

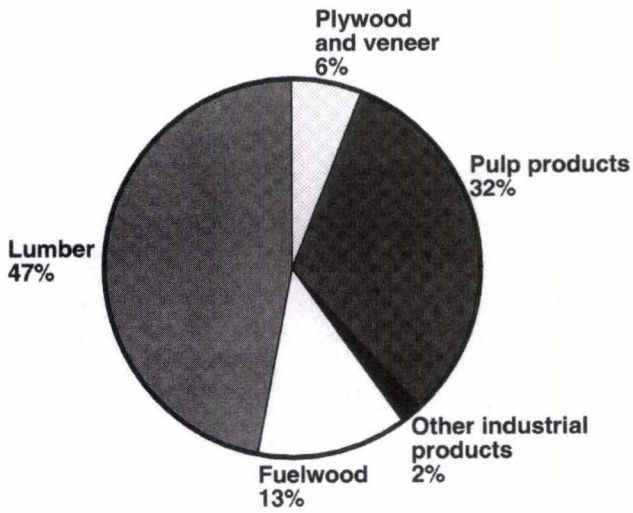

Figure 4.6—*U.S. consumption of timber products by product type, 1997. Annual consumption per capita is 74 cubic feet. (From Howard 1999)*

If per capita consumption in Missouri is equivalent to that of the U.S. as a whole, the 5.4 million people living in Missouri annually consume the equivalent of 400 million cubic feet of wood. This is more than the 267 million cubic feet of forest growth in Missouri and far more than the 117 million cubic feet of annual removals in the state. However, it is less than the potential growth if Missouri forests were intensively managed.

The U.S. is a net importer of timber products. In 1997, the equivalent of 91 percent of our national consumption (on a total volume basis) was produced domestically. Thus, unless the output of domestic forest products is increased, increased consumption of forest products will be supplied by foreign nations.

MISSOURI FOREST RESOURCES IN CONTEXT—FINDING A BALANCE

In some respects, forest resources in Missouri are a microcosm of forests in the United States (table 4.4). Like the United States as a whole, Missouri is about one-third forested. We have a proportionate share (1/50 or 2 percent) of the Nation's land area, forest land area, and population, and we consume a 2-percent share of the Nation's forest products. However, volume of standing timber, timber growth, and timber harvest in Missouri are proportionally lower—roughly 1 percent of the Nation's total. And the volume of cull trees (including rough and rotten trees) in Missouri is disproportionately large—9 percent of the national total.

Missouri is situated in the transition between the heavily forested States of Kentucky, Tennessee, and Arkansas and the agricultural (formerly prairie) States of Kansas, Nebraska, Iowa, and Illinois. From a landscape perspective, the high concentration of forest in southern Missouri is unique. The large forested area of the Ozarks is surrounded on three sides by landscapes dominated by agriculture (formerly by prairie and open woodland). Consequently, for recreationists, for migratory forest dwellers such as many of the neotropical songbirds, and for species such as black bears that have large home ranges, the large area of highly concentrated forest land in southern Missouri is a unique resource.

Missouri's forests are also a unique resource for producers and consumers of forest products. Timber volumes in Missouri are at their highest level in the last 50 years. Missouri's forests are a renewable natural resource that, if properly managed, can provide a steady or increasing flow of biodegradable, recyclable wood products from lands that are ill suited to other uses.

Table 4.4—*Missouri forest statistics compared with national totals. Compiled from Hahn and Spencer (1991), Howard (1999), Powell* et al. *(1994), and census population data.*

	United States	Missouri	Missouri as percent of U.S. total	Missouri rank (of 50 states)
Land area (million acres)	2,263	44	1.9	18
Forest land area (million acres)	737	14	1.9	25
Timberland area (million acres)	490	13	2.7	21
Population (millions)	249	5	2.0	16
Consumption of forest products (million cubic feet)	18,550	400	2.0	16
Growing stock volume (billion cubic feet)	786	9	1.1	25
Annual growth (million cubic feet)	21,626	267	1.2	28
Harvest volume (million cubic feet)	16,308	117	0.7	24
Volume of rough and rotten trees (million cubic feet)	55,678	4,857	9.0	1

With respect to forest products, it is essential to simultaneously consider the quantity of forest products consumed by Missourians along with forest growth and harvest rates. All are essential components of sustainable forest management at local and global scales. Because the U.S. is a net importer of wood, a reduction in wood production in Missouri will not necessarily improve global forest sustainability. Rather it may shift the demand for forest products to other states and ultimately to other nations where there is no assurance that sustainable management practices will be utilized (MacCleery and Strigel 2000).

Three things are clear from the statistics in the preceding sections. First, Missouri has an abundant timber resource that has steadily increased over the past 50 years. Second, forest growth exceeds harvest by a large margin. Thus, *on the basis of timber volume alone*, the current harvest volume appears to be sustainable and could be increased. Other factors certainly affect forest sustainability and must be considered, but in terms of timber volume the excess of annual growth over annual harvest is substantial. Third, Missouri citizens annually consume forest products in an amount far exceeding both the current annual harvest and the current annual growth. These facts lead to a number of interesting questions regarding sustainability and responsible stewardship of Missouri's forest resources:

- Can Missouri sustainably produce a quantity of wood equivalent (on a volume basis) to what we consume each year (i.e., 400 million cubic feet)?

- Can we reasonably expect a decrease in consumption?

- If not, what proportion of our consumption (on a volume basis) could we reasonably produce? Clearly local forests could not meet the demand for all the specific products used in Missouri (e.g., softwood dimension lumber), but on the basis of total volume could we increase forest harvesting to a level more nearly commensurate with our level of consumption?

- If we decrease timber output or fail to increase it in the face of increasing total consumption, where will the wood products we use come from?

- When we import wood from other states or other nations, are we simply ignoring the environmental consequences of our consumption by exporting the timber harvests out of sight?

- What are effective strategies for bringing consumption and production of forest products in Missouri in closer balance? Reduce consumption? Recycle more? Intensify fiber production? Improve management on private lands? Develop agroforestry systems?

- If we increase timber production, what are the impacts on water quality, aesthetics, wildlife habitat, and recreation?

- What are the local environmental consequences of producing more wood locally?

- What are the global environmental consequences of not producing more wood locally?

In Missouri we certainly could come closer to producing a volume of wood products equal to wood consumption by the State's citizenry. If nationally we are to maintain a balance among consumption and production of wood products, Missouri is a good test ground. Although average site quality in Missouri is lower than in many other states, there is clearly much room for increasing forest growth per acre. Missouri leads the U.S. in low quality, rough and rotten (cull) trees. Recruiting new trees to replace a large proportion of those low quality trees would dramatically improve the annual growth of growing-stock trees in the State.

Sustainable management requires consideration of local and global impacts of management decisions. Missouri's timber resource presents both challenges and opportunities. Defining a future direction requires a full understanding of the condition and productive capacity of Missouri forests, the demands we place on forest resources through our consumption of forest products, and the local and global implications of our decisions about where we obtain the resources we consume.

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Non-Timber Forest Products: Potential for Sustainable Forest Income

Shelby G. Jones[1]

Abstract.—Forests are capable of producing income for their owners from a vast variety of products other than saw logs and veneer logs. While the conventional products require many years to produce, it is possible to develop annual income from many non-timber products. Common sense management can produce non-timber products sustainably so that they become a permanent portion of forest productivity. This article will familiarize readers with some of the more common non-timber forest products and their potential markets.

Forests have provided much more than wood fiber for human use throughout our existence. Modern people, however, have focused upon forests for production of lumber, veneer, firewood, pulpwood, posts, poles, and many other solid wood commodities. Forest management activities have concentrated on production of these commodities and, to some extent, ignored non-timber items that can contribute to everyday living necessities. With greater appreciation of the total forest ecosystem by the general public has come renewed interest in non-timber products and their commercial economic potential.

Missouri hardwood forests contain a diversity of species providing a virtually endless variety of potentially marketable materials without regard to the location of the forest or the size of ownership. Sensible harvesting of many products can be sustainable on an annual or short-term basis, adding a new dimension to long-term investment periods associated with conventional forest management. Thus, non-timber products provide attractive economic options allowing landowners to realize income during the period required to produce conventional forest products. Forest land that is capable of generating even small annual revenues is more likely to be sustainably managed by a majority of landowners.

The marketplace for many non-timber forest products is quite diverse, providing many options for landowners to enter at any level with which they are comfortable. For example, some products may simply be harvested and sold at local markets without further processing. Wild edibles such as berries, fruits, nuts, and mushrooms are examples of items that are often personally marketed in fresh condition by rural or surburban owners residing on their land. Non-resident landowners most often derive income by receiving a fee from collectors, harvesters, or home processors who concentrate marketable quantities from a number of local ownerships. Value is added by cleaning, processing, packaging, and merchandising. Non-timber forest products offer many opportunities for home-based business development utilizing locally grown raw materials marketed in the local area. Of course, the locally successful entrepreneur can also expand into regional, national, or even international markets.

A list of these potential products would number in the thousands, giving every owner a unique opportunity to select something that fits his/her specific resource and management situation. Even small acreages are capable of producing products. Recreational properties of only a few acres can be just as productive for products as a tract of several hundred acres. If you own forest land and would like to explore ways to generate short-term income from it, the next few paragraphs should prove interesting. Likewise, non-landowners may find opportunities for value-added businesses.

This group of products is known by several names: special forest products, alternative forest products, or non-timber forest products. No matter what you call them, the diversity of Missouri's forests becomes evident as we identify some of the products. While many have been aware of many of these products for a

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long time, there are probably surprises for everyone. Modern society has lost its familiarity with many ancient remedies and its taste for wild food items. However, the current popularity of naturopathic medicines and health food supplements is renewing interest in medicinal compounds derived from plants, many of which grow in forests. Wild edibles are of interest to many who find organically grown foods desirable. As we take a closer look at some of these products, ask yourself what similar items might be growing on your forest land. In a sense this article is meant to stimulate your thinking about new ways to make your own forest land more productive.

CONES AND SEEDS

Cones from coniferous species offer a variety of market possibilities (Thomas and Schumann 1993). Since the cone contains seed, one of the most obvious markets for ripe cones is for seed to supply tree nurseries throughout the country. Cone harvest is sometimes done in conjunction with a timber sale timed to occur when the cones are ripe. Cones can then be more easily picked from the tops remaining following the removal of logs and pulpwood. Some companies specialize in this business, paying landowners for the rights to harvest cones. Of course, a landowner could also harvest and sell cones to a seed broker or dealer. Sometimes, for specific purposes, trees are climbed to pick cones, but this is best left to the professional.

Opened cones are also in demand for various floral, wreath, and potpourri products. Following seed extraction, many nurseries now sell opened cones to craft markets. Almost any species of cones, from very small fir cones to large ponderosa pine cones, are marketable. Cones are most often sold based on weight, but may also be sold by volume (e.g., bushel) or may be individually priced for very large or unusual specimens. Prices average $.30 to $.60 per pound or the equivalent.

Hardwood seed crops can be handled in a similar manner. There is a growing market for seed of both tree and shrub species for native plant nurseries. These nurseries are experiencing increasing demand for native plants to be used in landscaping, windbreaks, shelterbelts, and other horticultural uses. Seed from understory plants and shrubs, especially those that have showy flowers or foliage, are equally desirable. Seed from medicinal plant species may be marketed for cultivating these plants in a controlled environment. A thorough inventory of *all* your forest plants would be a good idea to determine if you have potential for harvesting multiple seed crops.

Prices vary according to relative abundance of the species and the difficulty of harvesting the seed. Price lists are available from larger seed dealers and seed supply wholesalers. Landowners can harvest seed themselves or sell harvesting rights to a seed collection company. At this time, seed certification programs do not generally exist for most species, but timing of harvest and care of seed following harvest are important to ensure quality and maximum viability. Seed production is variable, even in local areas. For consistent income it is suggested that Missouri landowners focus on several different species and become familiar with seed production requirements for each. You should also check for special State regulations regarding the species being harvested, although there are few restrictions for harvesting on private land. For example, some states have special regulations prohibiting seed collection along highway rights-of-way, public lands, and parks. Harvesting seed from rare and endangered species might also be restricted or prohibited. The best initial contact for information specific to your area might be your State forest nursery manager or a seed collection company.

TREE AND SHRUB POLLEN

Tree pollen is a very evident product of the forests during early spring and summer for those suffering allergies (Thomas and Schumann 1993). However, very few allergy sufferers would even think of pollen as a marketable product from forests. Pollen production will be a potential income source for only a few forest landowners, but it is one that fits unique situations.

Plant pollen should not be confused with bee pollen and its health food aspects. Tree, shrub, grass, and weed pollens are used mainly for production of allergenic medicines and allergy testing. There are only a few processors of tree pollen in the U.S., and most are associated with large pharmaceutical companies. These companies collect pollen with their own personnel operating under the guidance of a professional botanist. They also purchase raw

material from a relatively small number of trained collectors located throughout the country. These pollen collectors harvest flowering structures from trees and shrubs on their own land as well as on land of other private owners.

Quite often collectors will travel from their local areas to more distant areas as the pollen "ripens" geographically. Collectors who operate outside their local area usually develop a number of collection sites on private forest land and pay the owners a percentage of the value of flowers harvested on their lands. As relationships develop, pollen may be collected every year on the same land, thus offering the fortunate landowner an opportunity for annual income. Other than maintaining the desired species of trees, there are no real questions of sustainability associated with pollen production.

Pollen collectors are actually "flower collectors." Thus, tree pollens are collected in the spring when most trees flower. Only the male flowers or portion of the flower (*Anther*) is used, but most collectors pick and sell the entire flower structure. Some plants have separate male and female flowers (example, sycamore and hickory) simplifying collection from those species. Other species, like cottonwood and redcedar, occur as either male or female plants. Of course, the most common situation is for flowers to contain both male and female parts, such as American elm. The greatest volume of pollen is collected from species that occur over a large geographic range and produce large amounts of wind-disseminated pollen. It is this pollen to which people are most commonly exposed. Allergenic proteins in the outer wall of the pollen grain are the culprits that actually cause allergic reactions in humans. Pollen grains are microscopic, but distinctly identifiable by species, making diagnosis of specific allergies possible.

Pollen collectors locate and collect flowers based on the projected needs of the processing companies. Processors provide this information to their regular collectors near the first of each year. New collectors are trained to accurately identify the species of plants they are collecting and to recognize when the flowers are ready for harvest. Collectors also partially dry the flowers prior to shipping to the processors. Collectors are usually paid on a weight basis for their dried flowers. The price is based upon the historic yield of pollen and the market value of the processed pollen. Prices vary for different species, but the species price is fairly constant from year to year. Collectors normally receive in the range of $5.00 to $40.00 per pound of dried flowers. Once the pollen is cleaned and processed, it can be stored for several years. Thus, the processing companies will purchase large quantities of a species that is exhibiting an unusually large "crop" in a particular year. Processed pollen must meet exacting standards for purity and is sold to pharmaceutical companies who further refine it into liquid extracts.

Tree pollen collection occurs over a relatively short season of 6 to 8 weeks in early spring, even if collectors follow the season northward. During the collection season, collectors may work long hours and require specialized equipment. Tree pollen collection should be considered only as a supplemental income possibility in most cases. For this reason, many pollen collectors are involved in other businesses such as tree arboricultural services, forestry, medicinal plant collection, seed collection, or farming.

Flowering structures are harvested by several different methods:

1. Trimming trees and hand stripping the flowers or collecting branchlets and flowers.
2. Hand picking flowers from standing trees.
3. Vacuuming pollen directly from the flowers.
4. Shaking trees mechanically and collecting pollen on plastic sheets under the trees.

If you are interested in becoming a pollen collector, at least one company offers a free leaflet briefly explaining the process. You can request the leaflet "Collecting Allergenic Pollens" from: Allergon Division, PO Box 693, Carthage, MO 64836, USA. State forestry agencies and State cooperative extension services may also have information about pollen collection activities in their respective states.

DECORATIVE WOOD AND HORTICULTURAL PRODUCTS

Unusual parts of trees such as burls, conks, and shelf fungus are desirable for many craft or artistic purposes (Thomas and Schumann 1993). Artistic painting, wood burning, and wood turning are just a few processes that turn these natural materials into marketable

products. Distorted grain patterns, natural color variations, or unusual textures are characteristics that appeal to craftsmen who produce wood turnings (HUT Products Catalog 1999), veneer, carvings, or artistic sculptures. These materials may come from species of trees and shrubs that have no other commercial value. A good example is willow walking sticks from willow infected with canker (Josiah 1999). When the bark is peeled off, the wounds from the canker infections create diamond-shaped patterns, giving this material the common name "Diamond" willow. In Missouri, oak, hickory, willow, redcedar, walnut, sassafras, and staghorn sumac are harvested when 1 inch to 2 inch in diameter for walking sticks. Some have faces carved on the top, others are debarked, while many are simply cut and dried before marketing. Wholesale prices average $1 to $2 per 3- to 6-foot stick. Markets for walking sticks are far from saturated.

Cypress knees, fruitwood grafts, pine knots, knot holes, and limb crotches are a few more products worth mentioning. All can be marketed through craft supply outlets, carving shops, and specialty wood supply houses as well as local craft shows. A few specialty wood supply catalogs also list a variety of these types of products. Horticultural supply companies occasionally stock this type of material for specialty bouquets, floral arrangements, bases, and other uses. Don't overlook branches and twigs as products. Unusual bark formations, colors, texture, buds, or shape are desirable for horticultural product markets. For example, pussy willow branches are often seen in floral arrangements.

Oak, hickory, willow, ash, and elm branches and stems, with bark still attached, in a diameter range of 1/2 inch to 1 1/2 inches are purchased for manufacture of bent-wood or rustic furniture. Fresh 4-foot sticks sell for approximately $.50 each. Longer sticks, up to 10 feet long, sell for more. Eastern redcedar is also used for similar products. Sticks can be shipped to manufacturers via United Parcel Service in bundles of slightly less than 100 pounds.

Burls, figured wood, spalted wood, or woods of unusual color are also in demand for turnings, wood pens (HUT Products Catalog 1999), furniture panels, veneer, and many other specialty uses. These are items that are relatively scarce and highly desirable, so it is not uncommon for them to be sold individually. Spalted wood usually develops in logs or trees that have been lying on the ground for some time and the decay process is just beginning. Spalting usually occurs in the sapwood portion of the tree, and the heartwood may still be usable for lumber or other solid wood products. Lighter colored and less durable woods generally "spalt" more readily. Species containing extractives, such as redcedar or walnut, usually do not develop spalting. Hint: Old log decks sometimes are a good source of this material. Decorative woods are generally sold by weight. The price per pound is highly variable and depends on the species, rarity, and quality of the item. It is not uncommon for items in this category to change hands many times before being processed into a consumer product. Global markets are very active. The Internet is very helpful in locating dealers and individual markets.

MEDICINALS AND PHARMACEUTICALS

Medicinal compounds used for naturopathic remedies include a large number of herbs used to make teas and oils that are alleged to have curative or therapeutic effects on common ailments (Thomas and Schumann 1993, Foster 1995). Actual medicinal properties are sometimes speculative, but these markets are well established and expanding. There are, however, plants and trees that contain specific chemical extractives used by manufacturers of pharmaceutical drugs. Wildcrafting or gathering these plants has historically provided income for many rural families. Although cultivation techniques for these species will eventually ensure uniformity and sustainability of harvest levels, current demands exceed supply for some materials. Agroforestry cultivation techniques are currently being developed for many species that have desirable medicinal properties. More intense cultivation is one way of addressing concerns for depletion of natural populations. Common sense harvesting should always be the focus where natural plant populations are relatively sparse and overharvesting could easily occur.

Of course, pharmaceuticals are not the only use for many of these plants. Dyes, cosmetics, fungicides, and insecticides are additional products in this category derived from relatively common plants. Several botanical companies with headquarters in Missouri purchase and market botanical plant material throughout the world. All publish price lists and specifications for the

plants or plant parts, including roots, stems, bark, twigs, and foliage, that they regularly purchase.

There has been much publicity about the value of a few plant species that are in high demand. Some of these plants are relatively rare and may actually be federally or state listed as rare or endangered. Landowners are advised to become familiar with harvesting regulations that might be applicable if these plants are marketed. As mentioned previously, sustainability of wild populations of these plants should be a primary concern for everyone.

BARK

Bark is another item in demand for medicinal purposes,"natural" food supplements or flavorings (Thomas and Schumann 1993, Wilcox Natural Products 1999). Slippery elm is a good example of a species that is used for manufacturing medicinal products such as tooth ache gum. Slippery elm bark is stripped from small saplings, obviously killing the trees. Sustainability is a definite concern in this case. However, landowners with slippery elm trees large enough to produce seed might consider using some of the seed to plant small plantations grown exclusively for bark production. In this case, the bark of saplings might be more valuable than logs of a mature elm tree and have a much shorter rotation.

Thick (3- to 4-inch) cottonwood bark is prized by wood carvers because of its color, texture, and unique presentation options. Faces and caricatures are carved from the thick plates. Cottonwood bark carvings are often mistaken for walnut due to their similar color. Cottonwood bark is also used for bases for floral arrangements and crafts. It is softer than wood, but dense enough to maintain detail. Pieces sell for several dollars per square foot at craft and carving shows.

White and paper birch and aspen bark is also in demand for crafts, boxes, containers, and decorative uses in areas of the country where it occurs naturally. Bark with distinctive patterns (e.g., hackberry, winged elm, persimmon) or color may have a market in your area. On the negative side, sustainability can be a significant consideration for many bark products.

WILD EDIBLES

Wild edibles is a group of products that are familiar to nearly everyone, but most of us are aware of only a small portion of the edible products of a forest (Thomas and Schumann 1993). In general, we think only of things that we can harvest and eat ourselves, such as nuts, berries, and mushrooms. However, try to picture a much broader array of products that someone might use in making consumer products.

Wild edibles is one of the larger groups of potential products of the forest. As such, the opportunities for annual income for forest landowners offered by this group is also great. Landowners have many choices about their level of involvement when they make a decision to include wild edibles in their sources of income. Income may be as simple as charging a fee for picking wild stocks of berries or other fruits. Other landowners may choose to harvest these edibles themselves and sell to a wholesale market. Still others will choose to sell fresh edibles directly to consumers. A few landowners will harvest edibles and process them into value-added products themselves, either an intermediate product or something ready for the consumer. There is also the advantage of being able to harvest different products nearly year-round, late-winter being about the only time of year when edibles are not very abundant in timber stands. Of course, things like maple syrup make even this time of year productive in some areas of the country. Some examples of major wild edible groups are discussed below.

Berries and Fruits

Many species of berry-producing plants and vines grow under a forest canopy (Mater 1993). Blackberries, blueberries, gooseberries, huckleberries, wild strawberries, wild grapes, or even mulberries are some that come to mind. Markets for landowners might be as simple as allowing picking of wild berries for a fee, or picking the fruit yourself and selling it to individuals or local businesses for further processing. *AgriMissouri Buyer's Guide* (Missouri Department of Agriculture 1999) lists many processors and canners who process and market a wide variety of wildcrafted products. Almost all states have similar programs and services. This publication could serve as an excellent reference for landowners attempting to find existing

markets in their local area. In fact, these catalogs are excellent sources of potential markets for many special forest products.

Fruits such as persimmon, paw paw, choke cherries, and crab apples are used for specialty jams and jellies, confections, and baked goods. May apples and crab apples are used in jellies and preserves as well as in medicinal compounds. Paw paw is sometimes known as an "Ozark banana" and natural selections are being cultured for more consistent fruit production, larger fruit, and smaller seeds. The pulp of the fruit is quite high in vitamin C. The twigs and leaves contain compounds used as natural pesticides and anti-cancer medicines. If you have access to the Internet, visit the Web site: www.spoon.com (American Spoon Foods 1996), to see what a variety of gourmet products can be produced almost entirely from wild harvested fruits and nuts.

Edible Nuts

Black walnuts have been the major nut crop in Missouri for many years thanks to Hammons Products Company in Stockton, MO, the world's largest processor of black walnuts (Mater 1993). This company buys walnuts from producers in a 20-state area of the Northeastern U.S. For walnut delivered to a "huller," producers are paid $10.00 per hundredweight after the green outer husk is removed. In an average year, this company purchases and processes over 20 million pounds of nuts. Most of this volume comes from wild trees and is delivered to market by landowners. Native pecans are also collected and sold, but the majority of the annual pecan crop is sold directly to consumers at roadside stands or to commercial processors. Management of native pecan stands for nut production is increasing, but the market is still very open. Many of the "minor" nut species also have very active markets. Hickory in the South and Midwest offers much potential for market expansion. Butternut, chestnut, and hazelnut are other species where demand normally exceeds the supply.

Acorns are most often overlooked as edible nuts in the U.S., but they have much potential in international markets, especially the Pacific Rim. An individual landowner would have difficulty finding markets presently for acorns to be used for food stuff. However, in the future, marketing cooperatives with the capability of marketing thousands of tons of acorns are a distinct possibility. In the meantime, acorns are sold to plant nurseries mainly for seed.

Honey, mushrooms, maple syrup, herbs and spices, edible roots and tubers, and flavorings are other edible products of forests that are not readily identified as such by our present-day urban-dominated population. More detailed information about any of these products can be obtained in your local library or on the Internet.

Mushrooms

Wild edible mushrooms have largely been gathered and enjoyed by individuals when in season in the Midwest. Commercial wild mushroom gathering has been mainly associated with the Pacific Northwest. In fact, in both Oregon and Washington, sale of wild mushrooms to international markets annually generates several million dollars of income. No figures are available for Missouri.

With mushrooms considered a delicacy, good areas for gathering wild mushrooms are closely guarded secrets. Trespassing on another's "spot" has generated many conflicts. While most landowners will probably elect to pick their own mushroom crop, there is plenty of opportunity to collect fees for allowing access for this purpose. Knowledge of sustainability aspects is incomplete, but crops of wild mushrooms appear to be highly variable.

Prices received by gatherers for wild mushrooms vary by species and grade, but are rarely less than $1.50 per pound and may be as much as $6 per pound. It is not unusual to see even higher prices for scarce species.

Demand for mushrooms is great enough to generate much interest in cultivation of species such as shiitake. This species can be grown on short, small diameter bolts of oak. White oak is preferred. Holes are drilled in fresh cut logs, and wooden plugs inoculated with mushroom spore are inserted into the holes. Logs are then stacked in the woods or a controlled environment shed where they can be kept wet. Fruiting will normally occur 6 to 18 months following inoculation. A $30 cord of firewood can produce $400 to $500 worth of mushrooms!

Incidently, many mushroom operations eventually purchase suitable logs rather than cut the logs themselves. If you own land close by, perhaps this is a potential market for material removed in timber stand improvement or thinning operations. Bolts are generally cut in 4-foot lengths and sell for $1 to $2 each. Since fresh cut logs are necessary for optimum production, this is a market that must be arranged prior to cutting.

RECREATIONAL ENTERPRISES

Use of private forest land for recreational pursuits offers private landowners excellent potential for annual income (Thomas and Schumann 1993). The landowner has almost unlimited options in this area, from doing almost nothing to very intensive development. The old real estate adage of "Location, Location, Location," certainly is true here. If your land is located near population centers, your options are probably greater than if it is in a very remote area. However, remoteness is a commodity that can be marketed also.

Fee hunting and fishing have been sources of income in many areas of the country for many years and are a growing trend in Missouri. Perhaps as much as 25 percent of the rural land in northern Missouri is currently leased for hunting. Deer and turkey hunting generates the majority of leases, but upland game hunting leases for quail, pheasants, rabbits, and doves also have increased within the past 10 years. Waterfowl hunting leases may be the most expensive because the property must be marshy enough to attract moderately large concentrations of game or be situated close to public waterfowl preserves. Hunting leases are commonly negotiated on a per acre basis and may be as specific as allowing pursuit of game only during a particular season. For example, some leases may be for deer hunting only during the regular firearms season. A separate lease for the archery hunting rights might be negotiated with a different party. Likewise, separate leases for spring and fall turkey seasons could be negotiated with yet other parties. Hunting lease fees in northern Missouri commonly range between $2 and $10 per acre per season.

It is not uncommon for small groups of hunters to purchase small farms for the primary purpose of hunting. These groups generally initiate recommended wildlife management practices and rent the agricultural land to local farmers for crop production. Such groups also offer good potential for local entrepreneurs who could harvest and process alternative forest products from their land for a fee.

Urban families are now willing to pay for nature photography, harvesting of wild edibles, farm vacations, hiking, photographic tours, picnic areas, and bird watching, to name only a few. Landowners need only complete some specialized management and market their facilities creatively.

Allowing public access to your private property is not without risk (Kays 1997). Liability insurance rates vary widely for recreational enterprises. Insurance is a consideration that must be thoroughly investigated prior to any business startup.

SUMMARY

In this short article, only a few of the thousands of potential forest products could be named. For the innovative landowner or entrepreneur, however, these brief descriptions will point the way to specific products and markets. To begin research, I suggest that you obtain a copy of *Income Opportunities in Special Forest Products, Self Help Suggestions for Rural Entrepreneurs*; USDA Forest Service, Agricultural Information Bulletin 666, 1993. The initial printing has been completely depleted, but most libraries can obtain microfiche copies. Individual chapters may be downloaded from the following Web site at the Forest Products Laboratory in Madison, WI: www.fpl.fs.fed.us/documnts/usda/agib666/.agib666.htm

A Web site specifically devoted to special forest product information is maintained by Virginia Tech University and is regularly updated with information relative to the Midwest and other parts of the country: www.sfp.forprod.vt.edu

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Downstream Effects of Timber Harvest in the Ozarks of Missouri

Robert B. Jacobson[1]

Abstract.—The downstream effects of timber harvest in the Ozarks of Missouri can be evaluated by analogy to other geographic areas and by historical analysis of responses to past land use activities. Based on research from other geographic regions, timber harvest in the Ozarks would be expected to have minor effects on annual water yield and dissolved-phase water quality. The potential exists for haul roads to increase stormflow discharges and sediment yields. Of the possible downstream effects, sediment yield is potentially the most severe and difficult to predict; siting and design of roads are probably the most critical management concerns for minimizing downstream effects. Historical analysis shows that Ozark streams have been destabilized by past land use practices, primarily in the riparian zone. Therefore, present-day timber harvest takes place in a landscape where streams have lowered resilience to disturbance. Predictions of future downstream effects of timber harvest in the Ozarks are complicated by the inherent complexity of cumulative watershed effects and the lack of detailed, long-term instrumental records at appropriate scales.

INTRODUCTION

Timber harvest inevitably causes some measure of downstream effects. Changes in evapotranspiration accompanying timber harvest will generally result in change to the water balance and the distribution of water between baseflow and runoff. Changes in biomass uptake and soil conditions will interrupt nutrient cycles. Any disruption of the ground surface by skid trails, roads, or traffic will disrupt hydrologic pathways and provide opportunities for soil erosion at greater than natural rates. The combination of these changes can alter water yield, peak flows, water quality, and sediment yield.

The concept of sustainability in forestry practices generally includes the desire to restrict offsite, downstream detrimental effects to some level acceptable to society while maintaining long-term productivity of forest products (AF&PA 1999). This understanding of sustainability motivates the need to understand how timber harvest affects streams, how far downstream the effect extends, and how long the effects persist.

This paper is a review of downstream effects of timber harvest in the Ozarks of Missouri, the region responsible for 71 percent of the State's industrial roundwood production (Piva and Jones 1997). The objectives are to describe our current understanding of how timber harvest affects downstream areas and to synthesize recent geomorphology studies that indicate how Ozark streams have responded to historical and present-day land use disturbances. The Ozarks lack any long-term, instrumental record of hydrologic, water quality, and sediment responses at scales relevant to timber harvest. Hence, current understanding of timber harvest effects will be described in this report from state-of-the-art research developed elsewhere. Historical geomorphic studies provide a necessary long-term and broad-area perspective on stream responses. Although these studies provide important insight into how the Ozark landscape responds to disturbance, they cannot provide the quantitative predictive understanding needed to assess downstream cumulative effects of timber harvest.

PHYSICAL SETTING

The ability of the Ozarks to grow trees, the history of land use changes, and the inherent sensitivity of the Ozarks to disturbance from timber harvest have been determined largely

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by climatic and geologic characteristics. The Ozark Plateaus of Missouri (known locally as the Ozarks) is an area of humid, temperate climate. Average annual rainfall is 1,000 to 1,200 mm, and average annual temperature is 15 to 18°C. Ozark uplands have gently rolling topography with slopes of typically 0 to 12° and local ridge-to-valley relief of tens of meters. Adjacent to major river valleys, vertical bluffs and steep slopes are common and local relief is 75 to 200 m.

The Ozarks (fig. 6.1) are underlain by nearly flat-lying sedimentary rocks with small areas of metaigneous rocks. Lithologically, most of the rock is dolomite and cherty dolomite, with lesser contributions of limestone, sandstone, shale, and metavolcanics (Koenig 1961). The chert-rich bedrock of the Ozarks has contributed abundant chert gravel to the bedload of streams. Residual soils range in thickness from 0 to as much as 10 m. A description of soils on a typical Ozark landscape can be found in Hammer (1997) and in Meinert and others (1997).

Much of the area is cavernous and supports a karst drainage system. The karst drainage system has resulted in some streams that are dry most of the time, whereas other streams with similar surface drainage areas have springs that provide substantial, relatively constant baseflow. Because much of the residual subsoil is relatively impermeable, intense rainstorms that fill A-horizon storage can generate runoff that bypasses the karst drainage system.

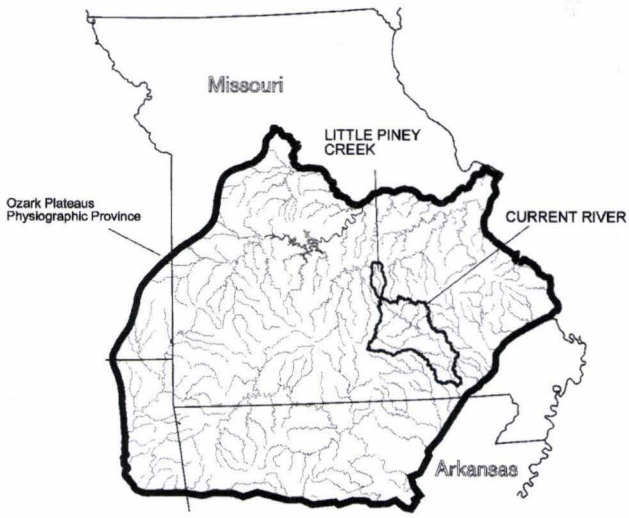

Figure 6.1—*The Ozarks of Missouri and adjacent states; Little Piney Creek and Current River drainage basins.*

The late Quaternary history of the Ozarks preconditioned present-day responses to land use. Three aspects of the Quaternary surficial geology are important determinants of land use effects. The first of these is the presence of windblown loess on the uplands of the Ozarks. Figure 6.2 shows an estimate of loess thickness (Thorp and Smith 1952), but some researchers believe the thicknesses shown on figure 6.2 are only minimum estimates (Johnson 1983). The loess is late Pleistocene in age and owes its origin to windblown transport from the Missouri and Mississippi Rivers (Rath 1975). The loess cap on Ozark soils has been a source of relatively fresh minerals to recharge soil nutrients, and it has provided better drainage conditions than the clayey residuum underlying most of the Ozark landscape. Erosion of the loess cap by natural and anthropogenic processes removes a soil resource that cannot possibly be replaced by weathering of bedrock in place.

The second aspect is the dynamic nature of erosion and deposition in the Ozark landscape during the late Quaternary. Hammer (1997) cited the presence of stone lines in soils and colluvial deposits to argue that erosion has been severe at times in the Ozarks. Mapping of colluvium (hillslope sediment) and alluvial (water-borne sediment) deposits along Big

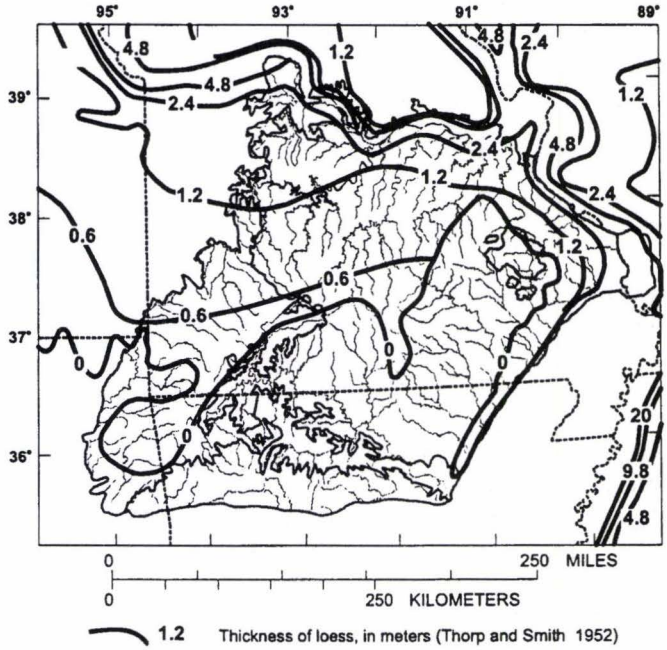

Figure 6.2—*Late Pleistocene loess distribution in the Ozarks, from Thorp and Smith (1952).*

Piney River and Roubidoux Creek in the north central Ozarks (Albertson *et al.* 1995) and in the southeastern Ozarks of Missouri (Meinert *et al.* 1997) has shown that colluvial deposits are widespread at the bases of slopes and in low-order valleys. Because of their locations in valley bottoms, local erosion of colluvium can deliver gravel directly to streams. Stratigraphic studies by Brakenridge (1981), Haynes (1985), Albertson *et al.* (1995), and unpublished data have put limits on the ages of some erosional events and demonstrated their episodic nature. Alluvial stratigraphy of the last 10,000 years demonstrates that alternating periods of erosion and deposition have occurred (fig. 6.3); correlations with pollen records support a climatic source for these periods of erosion and deposition. The most extensive deposit is the silt-rich Miller Formation, which has been interpreted as an aggradation of loess that had been eroded from the uplands during the early Holocene hypsithermal, a warm, dry period 9,000 to 5,000 years before present. Two exceptions to climatically driven disturbance are represented by the Ramsey Formation and the Cooksville Formation (Albertson *et al.* 1995). The Ramsey Formation has an unusually high content of charcoal and has been correlated with units on the Pomme de Terre River that are associated with Native American fires (Johnson 1983). The Cooksville Formation is the most recently deposited; the greater relative volume and coarse particle size of the unit have been attributed to anthropogenic disturbance and channel aggradation (Jacobson and Pugh 1992). The episodic nature of the stratigraphic record establishes that Ozark streams have been sensitive to landscape-scale disturbance in the geologically recent past; the scale of this disturbance presents a reference condition for assessing the impacts of future disturbance.

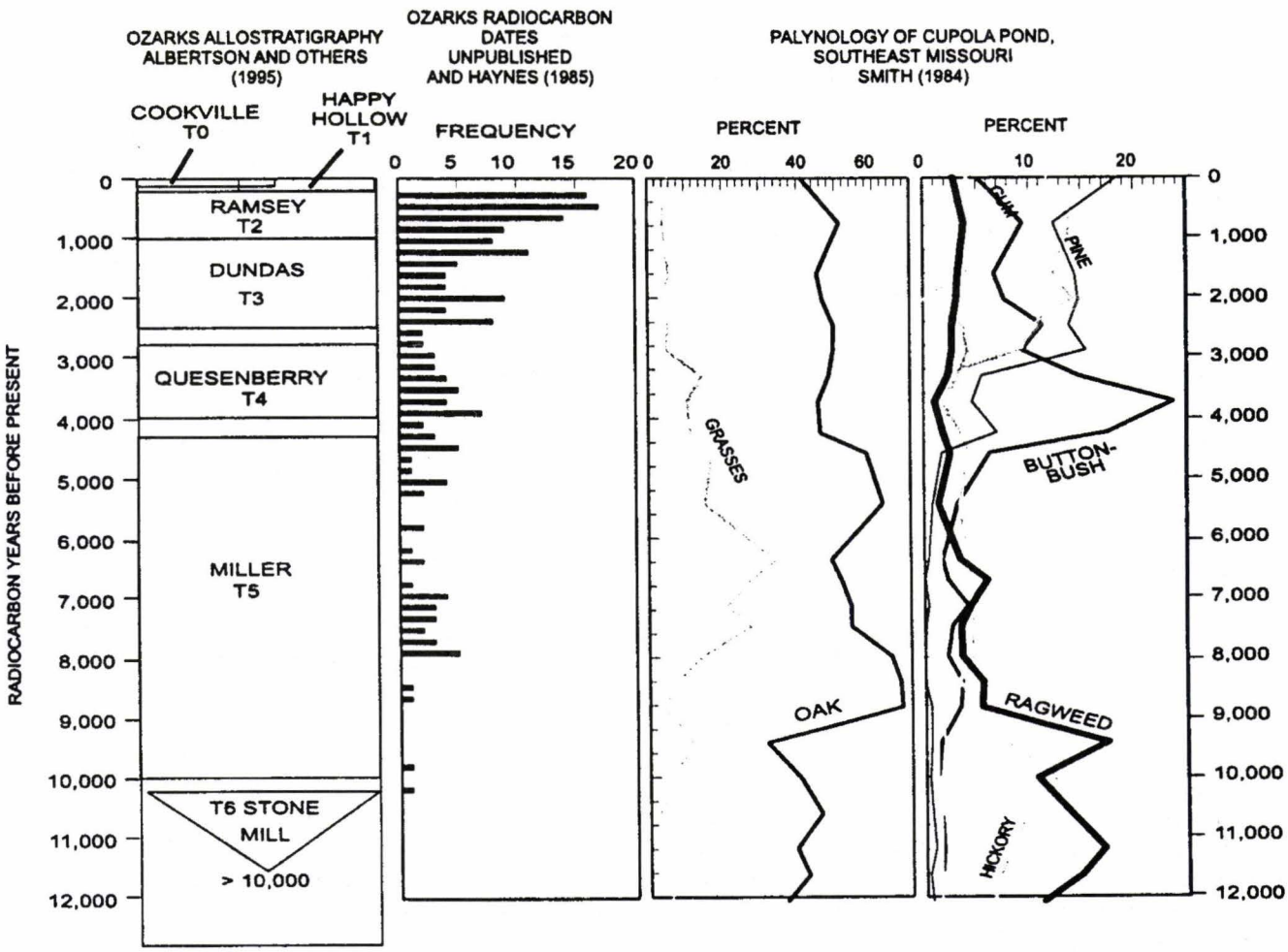

Figure 6.3—*Correlations of Holocene allostratigraphic units, numbers of radiocarbon dates, and palynological data, Ozarks of Missouri.*

Third, the Holocene stratigraphy reveals that extensive deposits of gravel underlie all parts of the valley bottom deposits of Ozark rivers (fig. 6.4). Although some additional aggradation of coarse sediment is evident in the Cooksville Formation, the more striking and consistent trend is a lack of fine sediment (silt and clay) in the most recent deposits. This is one line of evidence used by Jacobson and Primm (1997) to argue that post-settlement aggradation of Ozark rivers relates more directly to riparian factors that have decreased the sediment trapping efficiency of gravel bars rather than to massive influxes of gravel from slopes.

LAND USE HISTORY

Timber harvest has been one of many land uses in the Ozarks over the last 160 years. The complexity of land use changes complicates the process of isolating the effects of timber harvest in historical analysis. The combination of past and present land uses also potentially lowers thresholds of stream disturbance and therefore may increase the disturbance effects of present-day timber harvest.

Land use changes with the potential to create landscape disturbance at the drainage-basin scale began in the Ozarks in the 1830s. Initial rural settlement in the valley bottoms was followed by a timber boom period lasting from 1880 to 1920, during which highly valued yellow pine was harvested for the eastern timber markets and oak was harvested for railroad ties (fig. 6.5). After the timber boom, cutover land was used for open-range grazing and small railroad tie and specialty timber operations. One of the land use changes in the post-timber boom period was an increase in the use of fires to manage pasturelands. A tree-ring record of fire history in the Current River basin in the southeastern Ozarks revealed that fire frequency was relatively steady there until the late 1700s. Fire frequency increased to a peak during 1840 to 1880, had a minor resurgence from 1905 to 1915 in the post-timber boom period, and decreased as a result of fire suppression up to the 1970s (Guyette 1995). Recently, fire frequency has increased as public land management agencies began using controlled burning as a management tool for woodlands.

Typical land use changes are summarized for four southeastern Missouri counties in figures 6.5B-F. Cattle populations have increased steadily since the late 1800s (fig. 6.5B). Timber cutting was coincident with a peak in hog populations under free-range conditions; hog populations have generally decreased in Ozark counties since the 1930s (fig. 6.5C). The closing of free range in the 1940s and 1950s is reflected in the increase in improved land (cultivated crops plus fenced pasture; fig. 6.5D). During the 1940s and early 1950s, there was a peak in row crop agriculture in the uplands (fig. 6.5E), but droughty, infertile soils limited the viability of cash crops. By the late 20th century, most of the Ozarks had become a mosaic of about 60 percent forest and 40 percent grassland. Human populations peaked in the Ozarks around 1900 and then generally declined until 1960. Since 1960, human populations in most rural counties have grown slowly (fig. 6.5F), although human populations in some counties with urban, recreational, or military development have grown at substantially greater rates.

Oral historical accounts collected by Jacobson and Primm (1997) also provided insight into the linkages between land use practices and stream disturbance. Oral history respondents consistently described streams as shallower and wider than they used to be. Respondents were inconsistent about the presence or extent of gully formation accompanying timber cutting, but nearly all respondents talked about the ubiquitous presence of open-range livestock in the riparian zones of streams. Many respondents described accumulations of large woody debris (LWD) in stream channels that were removed to allow passage of tie rafts or burned for recreation. Additional information about the land use effects on stream disturbance history is contained in Jacobson and Primm (1997).

DOWNSTREAM EFFECTS: CONVENTIONAL UNDERSTANDING AND OZARKS HISTORY

Downstream effects of timber harvest can be categorized according to alterations of hydrologic characteristics, water quality characteristics, and sediment budgets. Hydrologic changes can be further divided into those that affect water yield and those that affect stormflows. Water quality changes include alterations of biogeochemical budgets measurable as changes in dissolved load or in terms of the chemical composition of suspended sediment. Changes in sediment budgets can result in

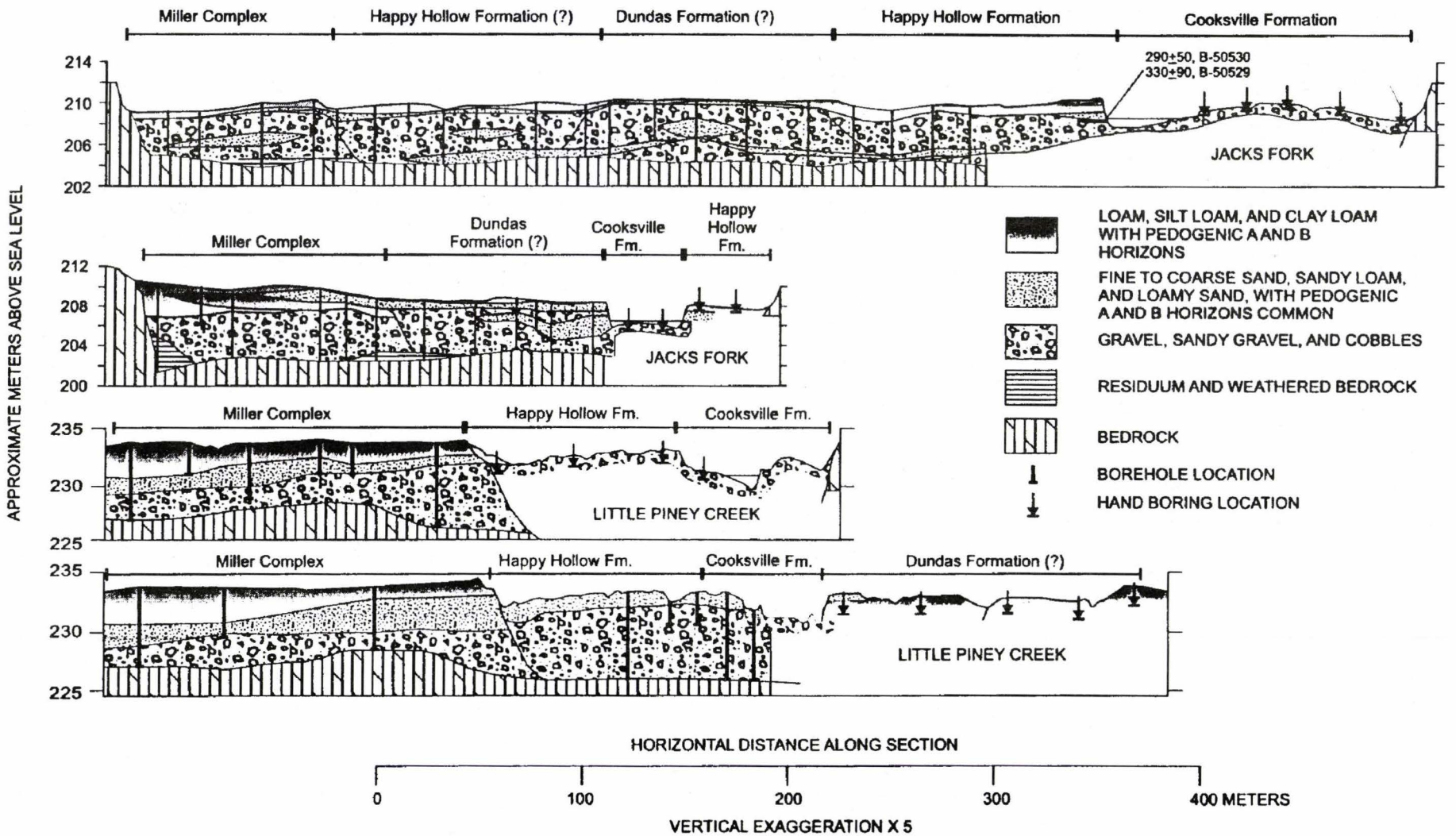

Figure 6.4—*Representative stratigraphic sections from Little Piney Creek and Jacks Fork (Current River basin) showing Holocene allostratigraphic units and relative quantities of gravel and fine sediment.*

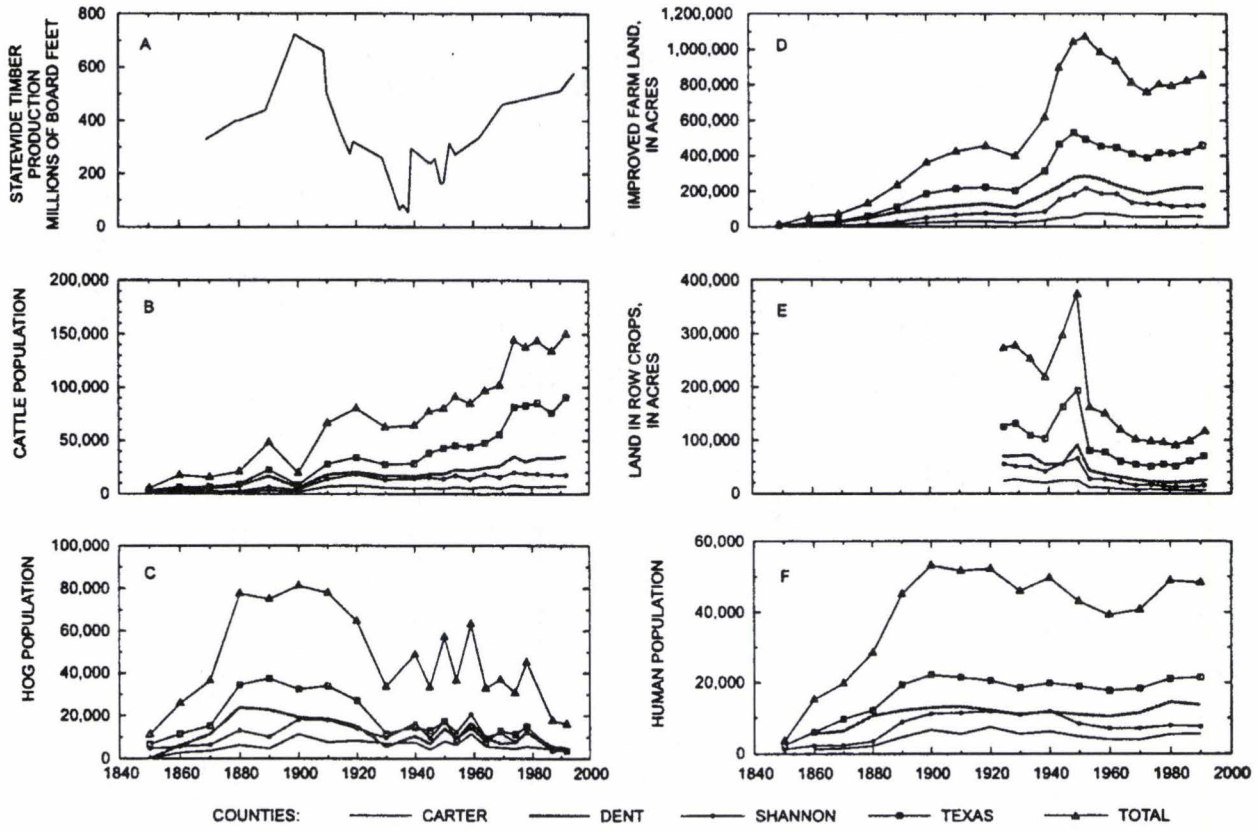

Figure 6.5—*Timber harvest data for Missouri, and land use data for four counties in southeastern Missouri (U.S. Census, 1850-1992): A, statewide timber harvest data in millions of board feet; B, cattle population; C, hog population; D, acreage in improved land, including cultivated crops and fenced pasture; E, acreage in cultivated crops (census category begun in 1925); F, human population.*

onsite degradation from soil erosion or offsite effects measurable in terms of aquatic habitat degradation, accelerated channel erosion, or excessive sedimentation. Whether timber management realizes any of this potential depends on many factors including geologic and climatic context, intensity of harvest, design of access roads and skid trails, accumulated history of landscape disturbance, timing of harvest, and spatial arrangement of harvest patches in the landscape.

In the following section of this report, downstream effects of timber harvest in the Ozarks are analyzed using two indirect approaches. Understanding gained from theory, and detailed field studies carried out in other geographic areas, are used to evaluate the general potential for downstream effects. Reasoning by reference to studies in other geographic areas is necessary because no long-term, detailed field studies of drainage-basin responses to timber harvest have been carried out in the Ozarks. Unfortunately, the geology, hydrology, climate, and land use patterns of the Ozarks are quite dissimilar from areas where detailed field studies have been accomplished, and this ultimately limits the utility of studies from other geographic areas. In the second indirect approach, historical landscape-scale information from the Ozarks is presented for its value in demonstrating past responses to land use changes and in limiting pathways of future responses.

Hydrologic Effects

Hydrologic effects of timber harvest can be further categorized into effects that increase water yield—the total water discharge from a drainage basin over an annual timeframe—and those that increase stormflows—the runoff from individual storms.

Water Yield

Timber harvest generally results in increases in annual water yield because of decreases in evapotranspiration (Douglass and Swank 1975, Bosch and Hewlett 1982). Increases for oak-hickory forest have been measured in the range of 17 to 62 mm/y. Studies in West Virginia documented increases in water yield of 8 to 64 mm/y for selective cuts up to 36 percent and an increase of 130 mm/y for clearcut lands (Lee 1980). A review of water yields associated with clearcutting in the Northeastern U.S. documented increases of 110 to 250 mm/y. These yields would seldom persist for more than 10 years unless tree regrowth was controlled by herbicides or fire (Hornbeck *et al.* 1993). On many landscapes, excess moisture infiltrates and recharges the water table to support summer baseflow (Keppler 1998). Where timber harvest practices decrease soil infiltration rates, direct runoff may be increased, and increased water yield would be manifested as increased stormflows rather than baseflow. However, because infiltration rates typically remain high compared to rainfall intensities and because compacted traffic areas are a relatively small percentage of the harvest area, excess moisture tends to infiltrate rather than run off (Patric and Helvey 1986). Deep infiltration delays recharge to streams and may actually increase summer baseflow and therefore increase aquatic habitat availability.

The magnitude of the effect of timber harvest on water yield decreases with increasing drainage basin size. This results from increased land use and geologic heterogeneity in larger basins. On Little Piney Creek in south-central Missouri (fig. 6.1), for example, a typical Ozark drainage basin with 512 km^2 area, instrumental records from 1928 to 1995 do not document trends in hydrologic changes that would be expected to accompany widespread reforestation of farm land over this same time period (fig. 6.6). No long-term instrumental records of streamflow are available for smaller, homogeneous basins in the Ozarks. A short-term study of the effects of cedar harvest on a sparse Ozark dolomite glade (watersheds of 0.30, 0.38, and 0.55 ha) indicated little effect of harvest on water yield (Krstansky 1986).

Stormflows

Decreased evapotranspiration and infiltration capacities plus incremental accumulation of deep soil moisture may result in increases in stormflows generated from harvested watersheds. Storm flow increases are generally associated with the effects of logging roads (Wemple *et al.* 1996). Actual increases in stormflow discharges—or decreases in lag times—have been difficult to document under field conditions without long, high-quality hydrologic records (see Jones and Grant 1996, for review). Recent analysis of instrumental records from paired basins in the Cascades Range, Oregon, has indicated that stormflows can be substantially increased. In 60- to 101-ha basins, stormflows were 50 percent higher for the first 5 years after treatment and remained 25 to 40 percent higher for as much as 25 years; increases for patch-cut basins of 60 to 600 km^2 area (12 to 25 percent harvested) were as much as 100 percent (Jones and Grant 1996). Peaks flows in this study included flows with return intervals greater than 0.4 years (flow that would be expected 2.5 times per year or with less frequency). An alternative analysis of the data used by Jones and Grant (1996) confirmed that stormflows increased after timber harvest in small basins, but found that harvest effects on stormflows were not detectable for flows with return intervals greater than 2 years (Thomas and Megahan 1998).

Investigations of the effects of timber harvest on stormflows in the California Coast Range also have shown increases of 16 to 35 percent for flows that occur less frequently than two times a year (Ziemer 1981a). This analysis indicated that intensity of harvest and a measure of antecedent moisture were important variables in modeling stormflow. Road density was not a significant variable in these basins because roads were all located on ridges and away from streams. Storm flow response was highly dependent on the sequence of precipitation events (Ziemer 1981a, 1998). When soil moisture is low, timber harvest effects are significantly greater than when soil moisture is high. Ziemer (1998) noted that stormflow differences between harvested and non-harvested basins were greatest for smaller, dry-season precipitation events that had little geomorphic consequence (little potential to transport sediment and affect aquatic habitats). Conversely,

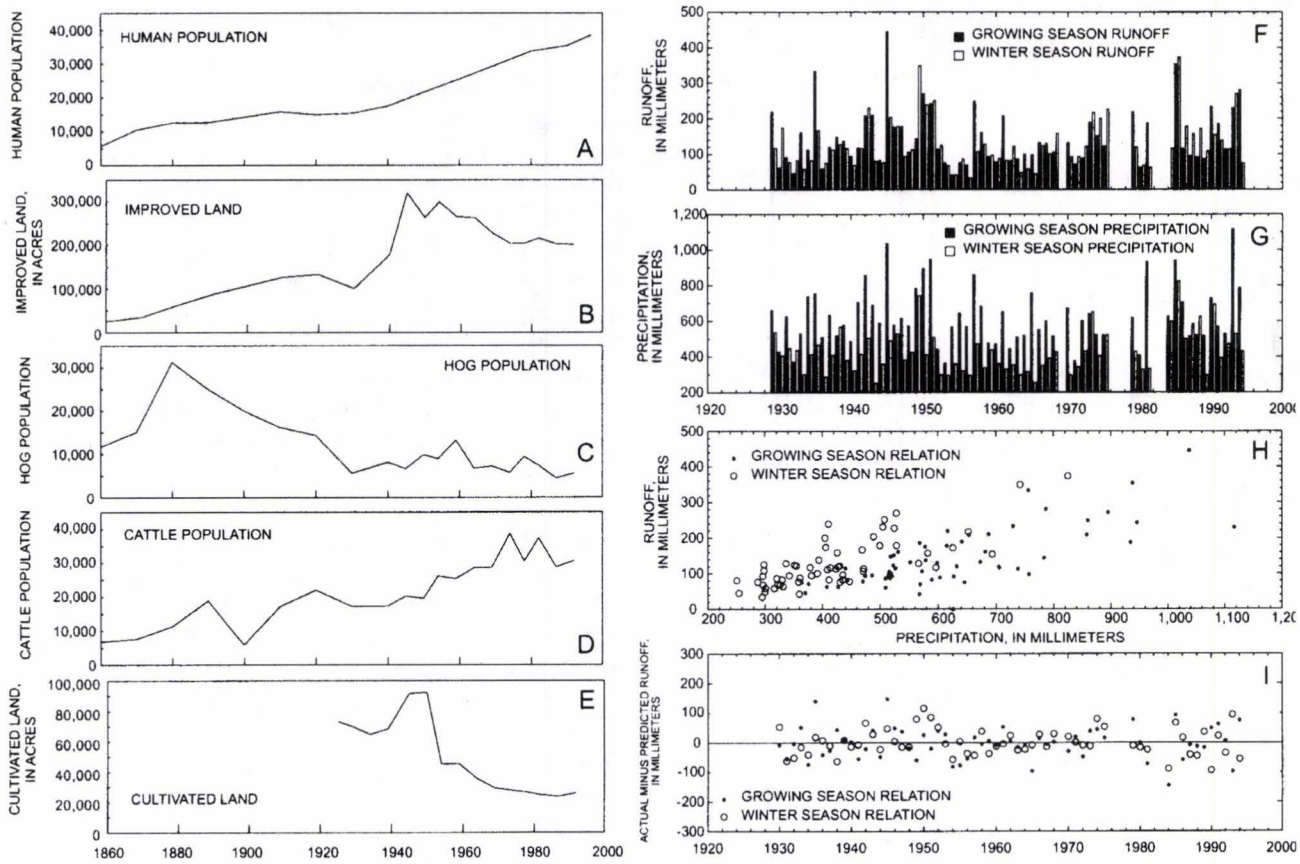

Figure 6.6—*Land use changes, seasonal precipitation, and runoff for Little Piney Creek Basin, Missouri, 1928-94: A-E, Trends in land use, Phelps County, Missouri, where the Little Piney Creek Basin is located; F, growing season and winter season runoff; G, growing season and winter season precipitation; H, scatter plots of runoff by precipitation, growing season and winter season; I, residuals of linear regression models of runoff as a function of precipitation plotted by years, growing season, and winter season. From Jacobson and Pugh (1999).*

harvest effects were smaller on less frequent, more geomorphically consequential flows.

Although some disagreement exists regarding the magnitude and persistence of stormflow responses to timber harvest, most researchers agree that access roads and skid trails have great potential to increase flows. Logging roads provide impermeable area, intercept through flow on cut slopes, and increase the efficiency for routing runoff from basins (Wemple *et al.* 1996). Therefore, the placement and design of roads is a critical management issue.

Increases in peak flow also have been attributed to processes that speed runoff and compress the hydrograph by decreasing lag times. Lag times can be decreased when channel conveyance is increased by increasing channel capacity and/or decreasing hydraulic flow resistance. These flow-routing factors can be affected by timber harvest in the riparian zone or direct alteration of the stream channel. As basins increase in size, factors that determine channel storage and hydraulic roughness tend to dominate over moisture-balance factors in determining storm flow discharges (Jones and Grant 1996). No long-term instrumental records of streamflow suitable for investigations of storm flow accompanying timber harvest are available in the Ozarks. Short-term, non-road plot studies from southeastern Missouri demonstrated that recently clearcut areas had as much as 10 times greater storm runoff than non-clearcut areas (Settergren *et al.* 1980).

Water Quality Effects

Water quality effects of land use change can be categorized into those that affect dissolved constituents and those that affect suspended

particulates. This section focuses on the dissolved load of streamflow, and the following section addresses sediment.

The disruption of nutrient cycles and subsequent accelerated discharge of nutrients to streams are often attributed to timber harvest (Hewlett 1982). Generally, this is considered a transient, pulsed effect that lasts until nutrient cycling is re-established by vegetative regrowth in the harvested area. The process of nutrient release can be particularly important to aquatic ecosystems if the nutrients contribute to the acidification of water in poorly buffered watersheds. In many areas, however, the short time period of the nutrient release pulse and the low relative concentrations of dissolved nutrients minimize the effect on streams. For example, nitrogen flux from a California clearcut basin was measured at only 1.8 kg/ha/y compared to < 0.1 kg/ha/y in a control basin; nitrogen fluxes decreased to < 0.4 kg/ha/y after only 3 years (Dahlgren 1998). In Finland, managed forests had 35 times the nitrogen and 2.5 times the phosphorous flux as that found in unmanaged old growth (Kortelainen and Saukkonen 1998). Post-treatment burning can also increase fluxes of nutrients dramatically (Malmer 1996). Henderson *et al.* (1980) concluded that timber harvest in the Ozarks can result in redistribution of nutrients within small watersheds, but that only a small portion of the nutrients is actually exported. In general, southern forests retain nitrogen after harvesting disturbance because of high C:N ratios and rapid regrowth of vegetation (Henderson 1985).

A small watershed study designed to detect the effects of cedar harvest on nutrient fluxes on an Ozark dolomite glade detected little change in fluxes of any nutrients (Krstansky 1986). The three watersheds selected for the study were very small (0.30, 0.38, and 0.55 ha) and had very thin soils and steep slopes. Increases in organic nitrogen flux were detected and attributed to particulate transport of organic materials. Independent of harvest treatments, atmospheric deposition of nitrogen was much greater than output, and output of phosphorous, calcium, magnesium, and potassium were all greater than atmospheric inputs. The latter effect was attributed to bedrock weathering in the drainage basins. A subsequent study of the effect of fire management on these experimental basins indicated that even under a burning regime, nitrogen is strongly retained (Amelon 1991).

Another perspective on the water quality effects of timber harvest comes from the regional variation of water quality associated with the range of existing land uses. The U.S. Geological Survey's Ozark Plateaus National Water Quality Assessment Program (NAWQA) has found clear trends of increasing nitrogen, phosphorous, and coliform bacteria concentrations with increases of agricultural and urban land (fig. 6.7; Davis and Bell 1998). Wooded land has much lower concentrations of these constituents. Similar regional observations on water quality and land use were made by Smart *et al.* (1985). Although these data do not isolate the direct or transient effects of timber harvest from increases in nutrients and bacteria accompanying agriculture and urbanization, they do illustrate the water quality impacts of alternative land uses in the Ozarks.

Sediment Effects

The EPA recently described sediment (siltation) as the number one nationwide stressor of U.S. streams (EPA 1996). In addition to altering physical habitat availability for stream invertebrates and fishes, sediment has been implicated as a transporter of adsorbed nutrients and contaminants (Meade *et al.* 1990). In a comprehensive review, Waters (1995) implicated timber harvest as one of the most pervasive sources of sediment and aquatic habitat degradation in North America. Waters (1995) synthesized a large number of studies from the Pacific Northwest, the northern Rocky Mountains, and the Appalachians and reached the conclusion that timber harvest is linked to accelerated sediment delivery through two dominant mechanisms: roads and landslides.

In contrast to this view, analysis of Universal Soil Loss Equation (USLE) erosion predictions from the 1982 Natural Resources Inventory (NRI) indicated that 94 percent of the forest land in the U.S. was eroding at or below indicated soil-loss tolerance values and spatially averaged rates were under 2.24 t/ha/y (1 t/ac/y; Sampson 1986). In addition, Sampson (1986) cited predicted soil erosion rates on grazed forest land that were, on average, four times higher than on non-grazed land. In a comment on Sampson's (1986) analysis, Renard (1986) discussed the general inadequacy of the USLE for quantitative

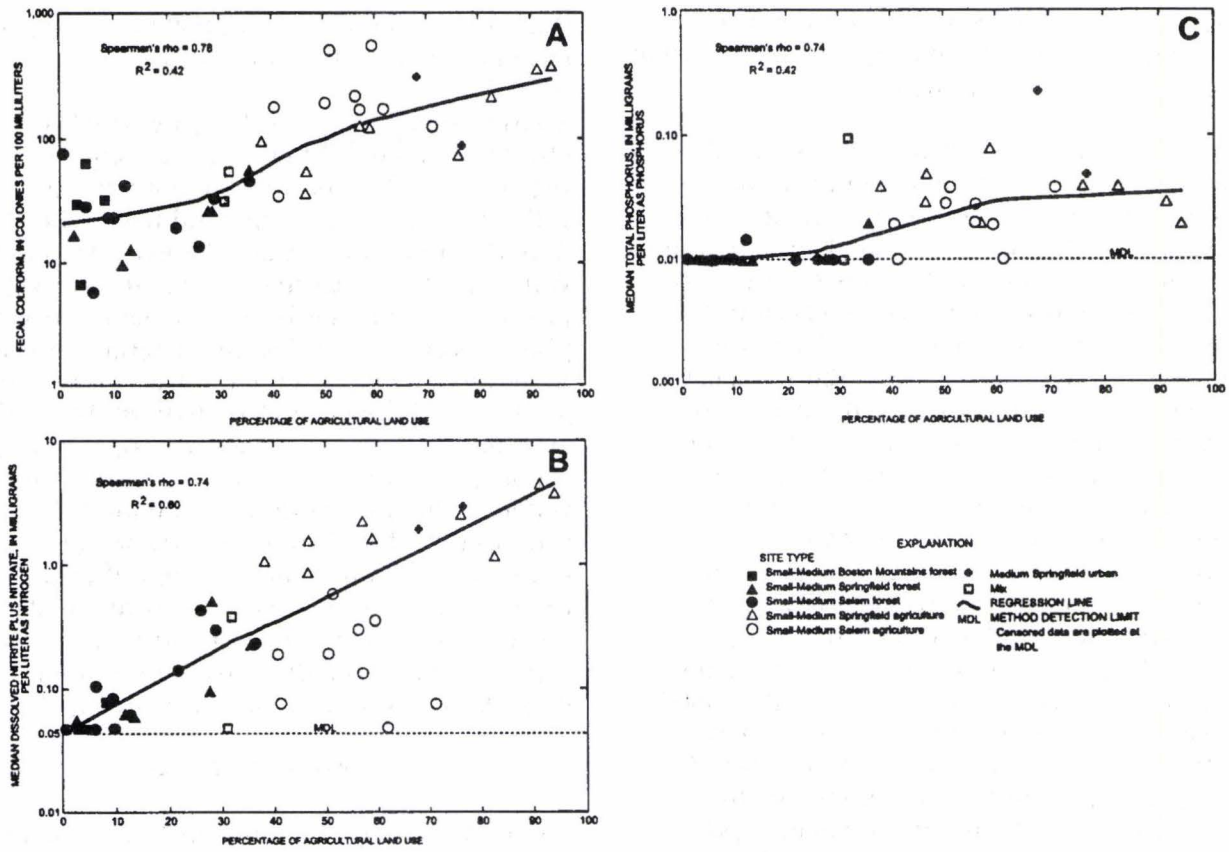

Figure 6.7—*Relation of major water-quality parameters to land use in the Ozarks. A. relation of fecal coliform counts to the percentage of agricultural land use; B. relation of dissolved nitrite plus nitrate concentrations to the percentage of agricultural land use; C. relation of total phosphorus concentrations to the percentage of agricultural land use. From Davis and Bell (1998).*

assessments of soil erosion processes on forested and range land. Stream-channel, road effects, and gully erosion are not evaluated in the USLE and therefore sediment yields may be far underpredicted for forest land. The NRI no longer calculates soil erosion predictions for forest land (NRI 1991), and earlier estimates of soil erosion from forest lands are probably poor.

Any disturbance of the forest floor during timber harvest is likely to create some increased sediment delivery to streams. Instrumental data, however, indicated that most non-road, non-streambank erosion yield is modest. Hewlett (1982) estimated that in the Eastern U.S. forest silvicultural (non-road) activities produced only 9 percent of soil erosion associated with the timber harvest. Like hydrologic effects, silvicultural sediment yield decayed rapidly to background levels over 5 to 10 years, but road effects persisted for as many as 30 years. Detailed investigation of sediment loads in the California Coast Range indicated 89 percent increases in suspended sediment loads associated with timber harvest, with yields as much as 2.8 t/ha/y (Lewis 1998). Field observations indicated that sediment loads could be heavily biased by landslide inputs and that sediment sources were dominated by streambank erosion and headward extension of channels rather than by sheet or rill erosion of roads, trails, or treated areas. Roads were not a significant factor in sediment yield in the Lewis (1998) study because they were located only on ridges and upper slopes far from streams.

In the Cascade Range of Oregon, a clearcut watershed had approximately twice the sediment yield of a control (Grant and Wolff 1991). This study also concluded that sediment yield results could be heavily influenced by individual landslide effects and individual large storms. Sediment yields in two harvested basins were 1.7 and 7.0 t/ha/y compared to 0.3 t/ha/y in a control basin. In contrast to the California study, Grant and Wolff (1991) concluded that failed road-fills were implicated as significant sources of sediment.

Most studies of sediment yield from timber harvest implicate roads as major sources. In the Idaho batholith area, road-related sediment yields were estimated to be 770 times greater than in areas without roads; 70 percent of the increase was due to landslides and 30 percent from surface erosion of haul roads (Megahan and Kidd 1972). Reid and Dunne (1984) reported 130 times more sediment yield from a heavily used road than from an abandoned, revegetated road. In a southeastern Australian study, roads also were found to be the most significant source of sediment from timber harvest, contributing 50 to 90 t/ha/y.

Studies of soil loss from timber harvest in the Appalachians concluded that managed eastern forest lands erode on average at the very small rate of 0.1-0.2 t/ha/y (Patric 1976); this same report, however, also noted that logging roads are unquestionably the source of most soil lost from managed timber land and can contribute as much as 90 t/ha/y. Patric (1976) also observed that the second greatest source of sediment on managed timberlands was accelerated streambank erosion. The potential role of haul roads in producing sediment in the Ozarks also is shown by estimates calculated for average soil erosion rates (table 6.1). Unfortunately, no long-term instrumented watersheds exist for compilation of quantitative measures of sediment yield accompanying timber harvest in the Ozarks. Short-term, non-road plot studies from southeastern Missouri demonstrated that recently clearcut areas had as much as 100 times greater sediment yield for individual storms than non-clearcut areas (Settergren *et al.* 1980). Settergren *et al.* (1980) also indicated that precipitation variables, vegetative cover, and geomorphic factors provided little predictive capability for sediment yields from these plots, indicating the inherent complexity of sediment delivery processes.

Land Use Derived Sediment in the Ozarks: History, Thresholds, Lags, and Cumulative Effects

A historical understanding of the cumulative effects of timber harvest and other land use changes in the Ozarks has been developed through geomorphological studies. Historical studies depend on interpretation of a wide range of incomplete and non-optimum data to construct an empirically and theoretically defensible understanding of land use—stream linkages. These studies provide a necessary historical understanding of stream processes, but they may not provide sufficient quantitative understanding for many prescriptive interpretations. Nonetheless, these studies highlight the complexities of sediment source, routing, and fate, and the impacts of these factors on aquatic habitats.

Complex Response

Physical landscape systems typically have non-linear responses to imposed stresses (Bull 1991). Thresholds, lags, and routing of sediment in a channel network are collectively referred to as complex response (Schumm 1977). Mechanics of soil, streambank, and streambed erosion typically exhibit threshold responses because a critical shear stress is necessary to initiate motion. Once thresholds are surpassed (critical shear stress for movement is reached), the system can change rapidly. If runoff increases because of road construction, critical shear stresses in channels and on slopes may be achieved with greater frequency. Alternatively, thresholds can be lowered as a result of land use practices. A common example is decreases of soil shear strength as tree roots rot after harvest (Ziemer 1981b).

Table 6.1—*Recovery periods and erosion rates estimated for typical forest harvest practices and alternative land uses for the Ozarks. From Dissmeyer and Stump (1978).*

Timber harvest practice	Recovery period, in years	Estimated typical soil erosion rate, in t/ha/y
Natural—no treatment	-	0 – 0.76
Grazing	-	0.01 – 36.2
Logging (roads + trails + silviculture)	3	0.05 – 5.8
Burning	2	0 – 1.6
Skid trails	-	0.01 – 36.8

The volume of soil eroded is not equal to the quantity that reaches a given point downstream. Sediment movement through drainage basins differs substantially from movement of water and dissolved constituents; sediment moves much more slowly than water and can be deposited and episodically remobilized. For example, in a small, agriculturally disturbed basin in Maryland, it was determined that 52 percent of eroded soil remained on slopes, 14 percent was stored on adjacent flood plains, and only 34 percent was transported from the basin (Costa 1975). The proportion of sediment delivered to a point downstream becomes even smaller as drainage basin size increases and more opportunities exist for storage (Roehl 1962). The finer the sediment, the faster and farther it moves downstream.

The lags and transient storage of sediment can result in persistent sediment problems and cumulative effects long after the initial erosion. Lagged transport in a channel network can also lead to spatially cumulative effects as sediment from different basins merges or disperses downstream. Together the threshold, lagged, and cumulative responses determine a complex response to imposed stresses.

Complex geomorphic responses have long been recognized by scientists studying cumulative effects of timber harvest. Although substantial progress in understanding cumulative effects has been noted (Reid 1998), cumulative watershed effects remain extremely difficult to evaluate or predict: "Almost by definition, cumulative effects do not conform to simple cause-and-effect mechanisms essential to [deterministic] approaches. Instead they tend to be dominated by unexpected results and quirky behavior, and are highly contingent on particular sequences of events." (Grant and Swanson 1991).

Ozarks Responses to Land Use Change

The geology and late Quaternary history of the Ozarks have preconditioned responses of drainage basins to land use disturbances. The abundance of chert gravel produced in the weathering of the carbonate bedrock is especially important in determining how the Ozarks landscape has responded to land use disturbance. Under natural or disturbed conditions, soil erosion preferentially removes fine soil particles, leaving a gravel lag that is resistant to erosion (Krusekopf 1937). This erosional lag presents a threshold barrier to soil erosion and promotes lateral erosion of slopes rather than gully formation. Prehistoric events that surpassed the erosion threshold deposited large quantities of chert gravel in colluvial and alluvial sites (Jacobson and Pugh 1992, Albertson *et al.* 1995). These extensive gravel deposits are located in valley bottoms where modest disturbance to erosional or hydraulic resistance could cause immediate and direct sediment delivery to streams.

Over the years many authors in the popular and technical literature have written that Ozark streams became choked with gravel as a result of massive hillslope erosion caused by turn-of-the-century timber harvest (for example, Hall 1958, Saucier 1983, Love 1990). Stratigraphic analysis demonstrates that Ozark streams have always transported large quantities of gravel since—at least—the early Holocene (fig. 6.4; Albertson *et al.* 1995). Jacobson and Primm (1997) synthesized stratigraphic, land use, and oral history data to argue that the apparent aggradation of Ozark streams was more likely a case of channel instability and redistribution of gravel laterally and longitudinally. The disturbance was caused primarily by riparian land use practices that destabilized streambanks, caused fine sediment to flush downstream, widened and shallowed channels, and prevented re-establishment of vegetation on gravel bars. Open-range grazing of livestock was implicated as the most direct, widespread cause, although factors like valley-bottom roads, tie-rafting, removal of large woody debris, and row-crop agriculture were potential contributors on some streams.

Modest additions of gravel volume in flood plains of fourth- and fifth-order streams have been interpreted as redistribution of gravel from upstream and from the adjacent flood-plain deposits. Upland gullies of demonstrable post-settlement age are generally absent in the Ozarks (Jacobson and Primm 1997). In the absence of upland gullies that would be capable of transporting coarse bedload, headward extension of the channel network has been implicated as the source of additional gravel. The working model for destabilization of Ozark streams and downstream transport of excess gravel calls for upstream propagation of the destabilizing effects of riparian land use on

the banks and in the channel. Steepened, unstable reaches of streams cause increased lateral and vertical erosion in upstream-migrating headcuts, effectively *pulling* excess gravel into streams rather than *pushing* gravel from upland slopes.

Destabilization of streambanks cross two geomorphic thresholds. When streambanks were oversteepened by lateral stream erosion, they reached the point where tree roots on the banks were no longer effective in providing erosional resistance (fig. 6.8). In this condition, streambanks can be undermined and rapidly erode laterally across the valley bottom. This threshold has contributed to the lack of efficacy of streambank vegetation in stabilizing banks of Ozark streams of fourth-order and higher (Jacobson and Pugh 1999). Stable, convex upward banks opposite point bars will not re-form until channel migration reverses direction. Studies of channel migration rates (Jacobson and Pugh 1999, fig. 6.9) indicated that the time required for a typical Ozark stream channel to migrate across the valley and reverse direction is on the order of hundreds of years.

The other threshold applies to point bars where loss of riparian vegetation decreases flow resistance and deposition of fine sediment (McKenney *et al.* 1995). In a positive feedback loop, lack of fine sediment contributes to a lack of cohesive strength and water-holding capacity and thereby decreases the capability of supporting riparian vegetation. Where conditions have permitted vegetation to establish on point bars, deposition rates have markedly increased (fig. 6.10).

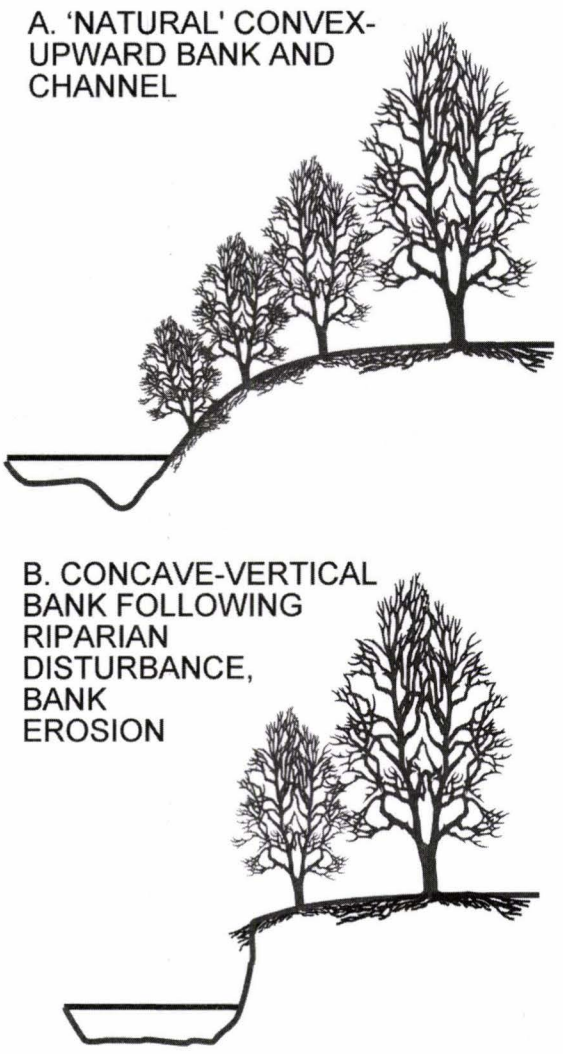

Figure 6.8—*Differing roles of roots on a convex-upward bank (A) and concave-upward bank (B). Roots are much less effective in resisting erosion on concave-upward banks. From Jacobson and Pugh (1999).*

Once Ozark streams became destabilized and excess gravel began to be transported downstream through the channel network, sediment routing in the channel network began to determine the extent of channel instability. Streambed elevation records from U.S. Geological Survey streamflow gauging stations indicate that in some parts of some streams, wave-like forms of gravel sediment have been transported past the gauges (Jacobson 1995, fig. 6.11). The wave-like forms are greater where dendritic-shaped drainage networks upstream of the gauges would promote merging of excess gravel transported from spatially uniform disturbances. Wave-like forms were minimal where trellis-shaped drainage networks would deliver excess gravel to streams at different times and places, thus minimizing cumulative effects. In a companion study, Jacobson and Gran (1999), demonstrated that the gravel-bar area along the Current River mainstem relates poorly to measures of present-day land use in tributaries. The present-day distribution of gravel-bar area (fig. 6.12), however, could be reproduced by a model that shows where and when gravel 'packets' would arrive on the mainstem, assuming uniform transport of gravel from first-order tributaries through the drainage network. The implication of this model is that relatively small disturbances caused by land use decades in the past can persist and grow to affect areas far downstream from their origins.

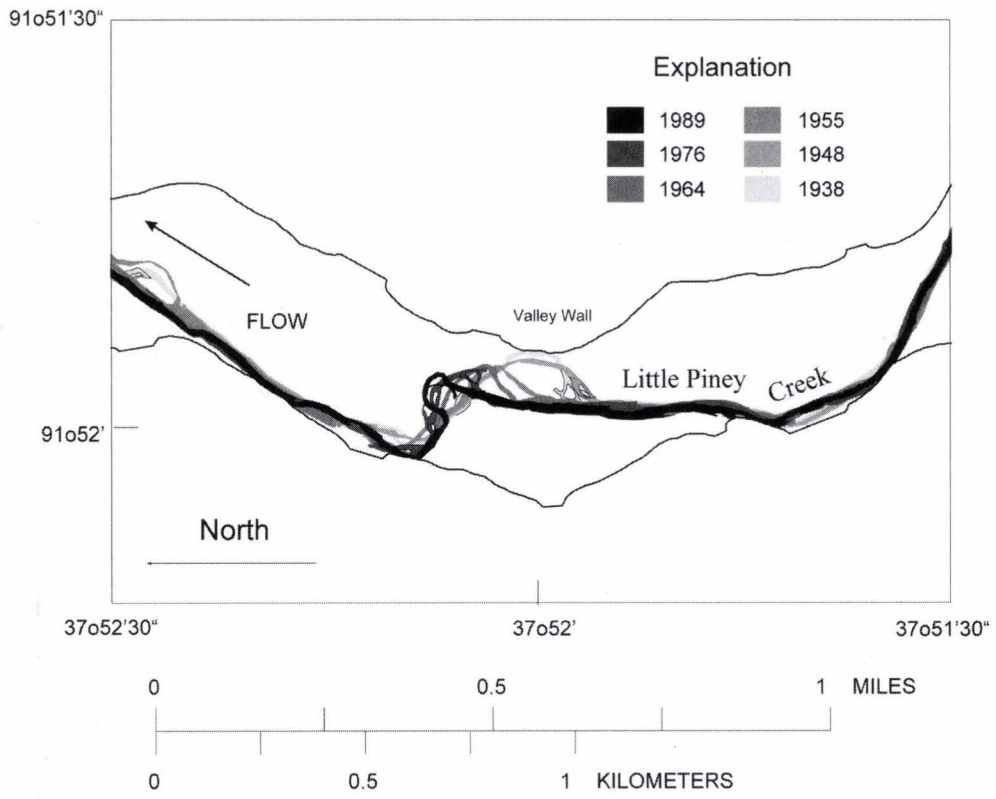

Figure 6.9—*Record of channel changes in a dynamic stream system over 50 years, Little Piney Creek, Missouri. There are distinct longitudinal differences in inherent channel stability within the river segment. From Rabeni and Jacobson (1999).*

The studies cited above concentrated on analyzing aggradation of coarse sediment (gravel and cobbles) in the Ozarks. Whereas the available evidence does not support the idea of massive influxes of gravel from hillslopes, there is ample anecdotal evidence that timber harvest and subsequent land use accelerated delivery of fine sediment (sand, silt, and clay) to streams (Jacobson and Primm 1997). The stratigraphic data show that most of the fine sediment was flushed from Ozark streams; however, fine sediment may well have caused habitat degradation during its relatively short time in transit by clogging gravel and filling pools. No suitable sedimentation monitoring data exist in the Ozarks to assess this potential.

Biological Links

Levels of downstream effects that are acceptable to society ultimately are determined by impacts on biota (including human society and natural ecosystems). Therefore, in addition to determining the links from timber harvest to changes in the physical system, we are challenged to determine the ultimate effects on biota. Resource management decisions may depend, for example, on stress-response relations between stormflows or sediment yield and fish or invertebrate populations. Substantial biological information on stream organisms has been collected in the Ozarks (for example, Matheney and Rabeni 1995, Rabeni and Gossett 1995, Peterson 1996, Doisy *et al.* 1997), but very little of this information is tied explicitly to an understanding of responses to changing physical processes and upstream timber harvest.

IMPLICATIONS FOR THE OZARKS OF MISSOURI

Until quantitative information is available for downstream effects of timber harvest in the Ozarks, lessons learned elsewhere can provide a first-order understanding. For timber harvest in which forest is regenerated after cutting, increases in water yield would be expected. Most of the increase would be expected as baseflow, measurable in small basins, but probably not measurable in basins that are large enough to mix in

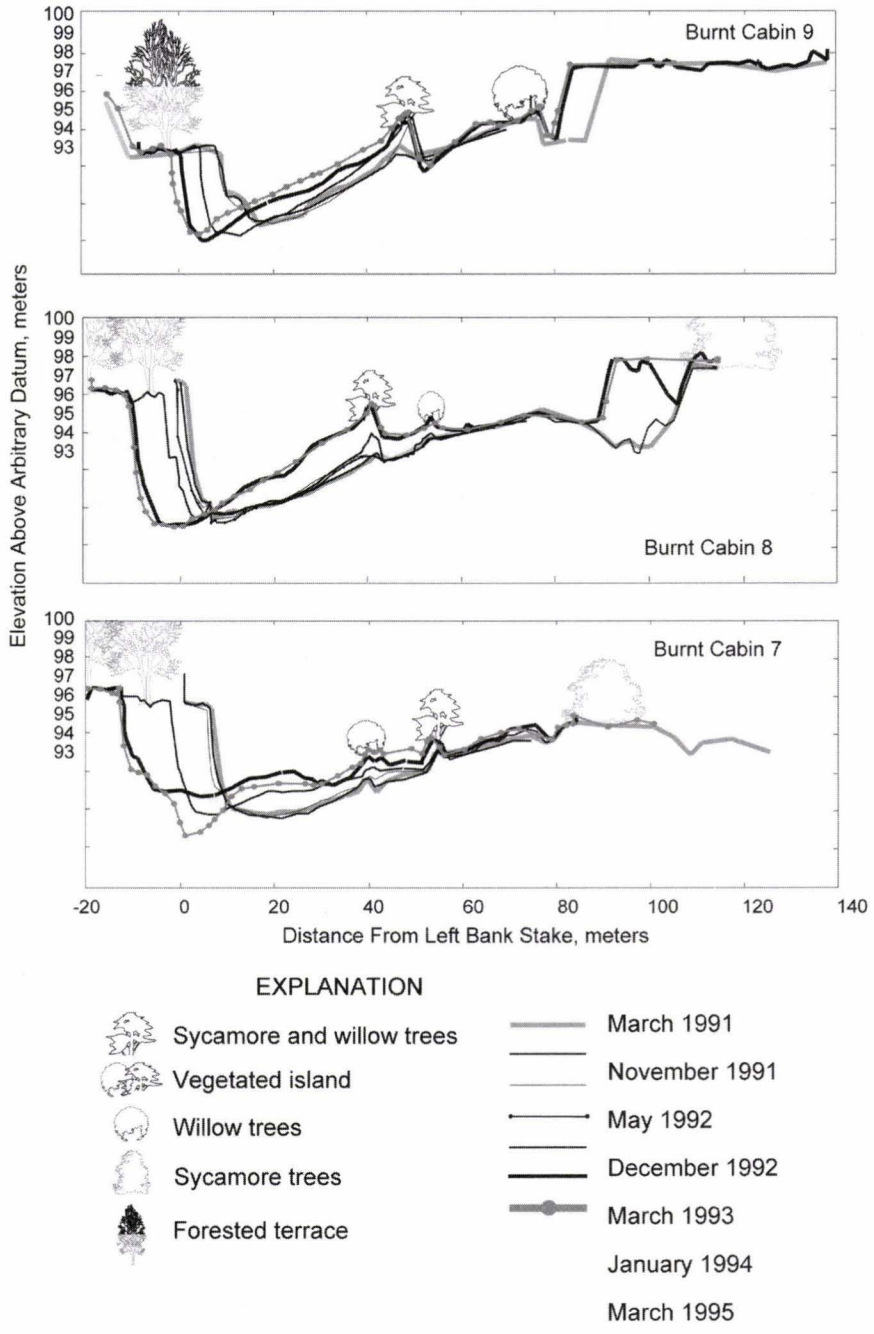

Figure 6.10—*Channel cross sections at the Burnt Cabin reach showing the morphologic change during March 1991-March 1995. Trees on cutbank (to left) provide minimal resistance to erosion; trees growing on point bar (to right) trap sediment by providing hydraulic resistance. From McKenney (1997).*

varied land use types. The water yield effect would be transient and would decrease to background levels in 10 years or less as evapotranspiration increased with vegetation regrowth. Stormflow increases may be significant in small basins, but because of high temporal variability in originating storms, the effects may be difficult to measure. The ability to detect stormflow increases attributable to timber harvest will decrease with basin size as flood-routing conditions in the riparian zone and a greater variety of land use types influence hydrologic responses.

Downstream effects of timber harvest on dissolved constituents in water will be small. Timber harvest pulses can disrupt nutrient

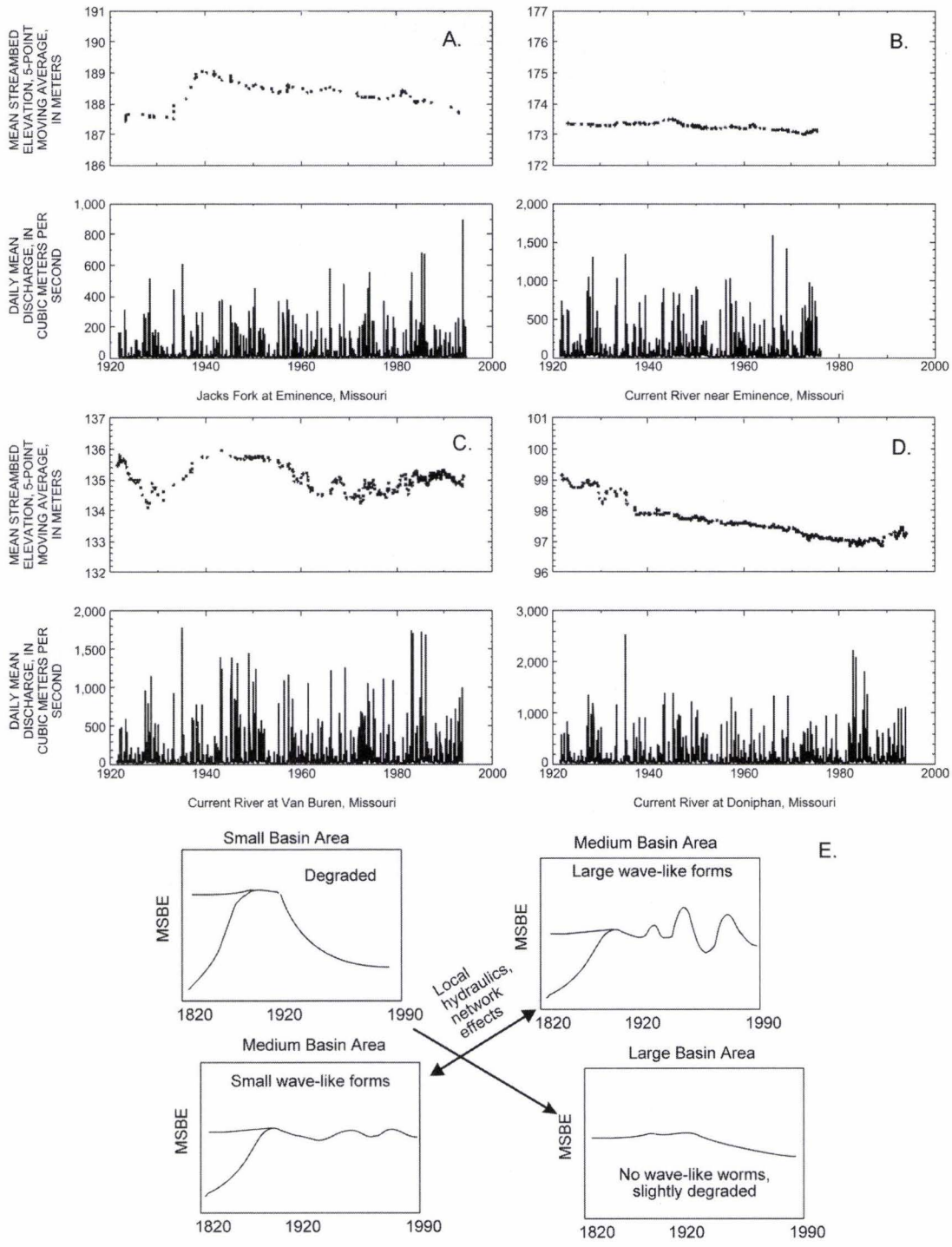

Figure 6.11—*Mean streambed elevation changes for streamgauges in the Current River Basin, showing variations in aggradation responses. A. Jacks Fork at Eminence, Missouri; B. Current River near Eminence, Missouri (near Two Rivers, Missouri); C. Current River at Van Buren, Missouri; D. Current River at Doniphan, Missouri; from Jacobson (1995); E. Schematic of controls on accumulation of wave-like forms at streamflow gauging stations. At midsize drainage basins, the magnitude of wave-like forms is controlled by drainage-network structure and local hydraulic controls.*

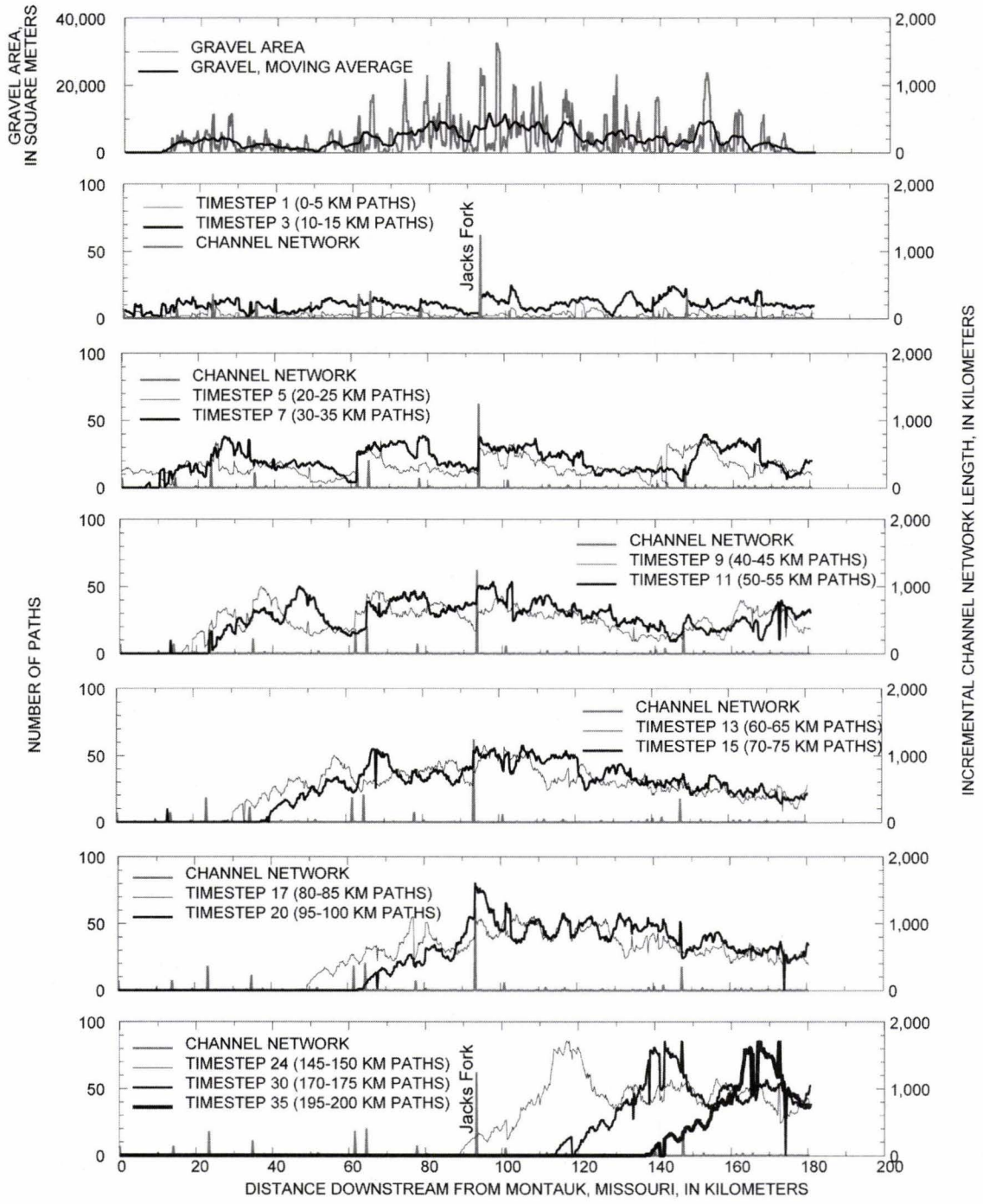

Figure 6.12—*Longitudinal plots of gravel-bar area and moving average of gravel-bar area along the Current River (top graph) and results of a simple sediment routing model that depicts how uniform transport of sediment from first-order tributaries would merge downstream as wave-like forms. The distribution at timesteps 7 to 9 (corresponding to sediment traveling 30 to 45 km) replicates many of the features of the actual gravel-bar distribution. From Jacobson and Gran (1999).*

cycling and release pulses of nutrients to streams; however, these pulses are short-lived and relatively small in magnitude. Effects of timber harvest on water quality are certainly small when compared to effects of alternative land uses such as agriculture and urbanization.

Timber harvest has the potential to accelerate soil erosion, especially from haul roads and skid trails. Unlike areas in the Pacific Northwest and Rocky Mountains where the effects of roads have been studied in detail, Ozark landscapes do not have particularly severe problems with landslides and road-fill failures.

Still, accelerated runoff from roads and the high erodibility of graveled road surfaces present considerable potential for increased sediment delivery. Roads can act as a source of sediment and as a source of enhanced stormflow runoff to first-order stream channels. Increased runoff in low-order stream channels may initiate bed and bank erosion downstream or contribute to continued upstream migration of headcuts.

Roads exert a more persistent stress than silvicultural activities. Silvicultural activities in the timber harvest tract disturb the ground surface during harvest, but erosion and sediment supply decrease quickly if woody vegetation or grass is allowed to grow back. In contrast, a haul-road network is usually designed for multiple harvest tracts and often is intended to last for multiple rotations. As such, the road network is potentially a large and persistent source of runoff and excess sediment.

Sediment yield and associated aquatic habitat degradation are lower for timber harvest than for many alternative land uses because timber harvest involves short pulses of disturbance instead of persistent disturbance. Conversion from timber to other land uses would involve persistent increases of water yield, stormflow, and sediment yield, and usually would include increased inputs of nutrients and bacteria. Hence, the downstream effects of timberland conversions would be expected to be substantially greater than the effects of timber harvest alone.

The spatial pattern of timber harvest within a drainage basin—how much is harvested at what rate, in which drainage basins, in what pattern—can be an important determinant of the magnitude and downstream cumulative effects of harvest (Grant and Swanson 1991). Although sediment delivery from an individual timber harvest may be modest, the delivery from other harvest tracts within the basin and at different times may be additive. The cumulative response of stream habitats to timber harvests scattered through time and space may also be governed by thresholds of irreversible change. Because timber harvest methods, socioeconomic conditions, and patterns of land ownership have changed in the Ozarks since turn-of-the-century timber cutting, the spatial pattern of disturbance caused by present and future timber harvest may be poorly represented by the historical record.

In the Ozarks, the cumulative response of stream systems to the total history of land use change can be characterized conceptually by hysteresis (fig. 6.13). The response to imposed stress (dominantly riparian land use) was slow until bank stability and riparian vegetation thresholds were overcome. After that point, channel disturbance rates increased substantially and accelerated in locations where the channel network enhanced accumulation. In such a system, the road to recovery is not simply the reverse of the road to destabilization; that is, there is a hysteresis response. Once destabilized, streambanks and gravel bars require time or specific conditions to redevelop resistance to disturbance. Present-day timber harvest in the Ozarks occurs within a system that has undergone historical destabilization and that probably has surpassed important thresholds of change. Additional marginal stress from hydrologic or sediment yield changes associated with timber harvest may be capable of maintaining instability and preventing recovery.

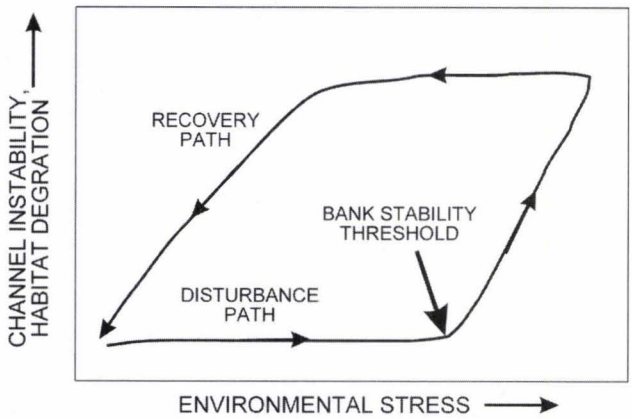

Figure 6.13—*Conceptual model of landscape hysteresis in the Ozarks. Riparian land use changes exerted increasing stresses along the disturbance path, but substantial changes in stream conditions did not occur until streambank thresholds were surpassed. After rapid changes in stream conditions, recovery requires formation of convex banks, a slow process that follows a different path. Additional disturbance during the recovery path would be expected to reverse the recovery path.*

CONCLUSIONS

The analysis presented here is the current, best understanding developed from multiple lines of imperfect evidence. There is much that is not known about how streams in many parts of the midcontinental U.S. will respond to hydrologic, water quality, and sediment stresses of timber harvest (table 6.2). The concept of sustainability forestry seems to encompass the idea that timber harvest will be planned to impose minimal and acceptable levels of environmental degradation downstream (Aplet *et al.* 1993). Sustainability cannot be claimed, of course, unless the downstream effects are measured. Noss (1993) observed that forest management involves considerable uncertainty, and given the uncertainty it is necessary to monitor ecological effects, evaluate their magnitude, and manage adaptively. Uncertainties in forecasting downstream cumulative effects are especially severe. Improved understanding of downstream effects of timber harvest (and other land uses) in the Ozarks will require an investment in long-term, detailed, quantitative assessment of responses at the drainage basin scale.

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Table 6.2—*What is known and what is not known about downstream effects of timber harvest in the Ozarks*

What we know (with some confidence)	What we don't know
• Timber harvest generally increases water yield, and enhances baseflows.	• Importance of spatial scale and pattern to downstream cumulative effects.
• Timber harvest has the potential to increase stormflows.	• The degree to which low-order Ozark streams have recovered from historical disturbance.
• Timber harvest effects on dissolved phase water quality appear to be minimal.	• Importance of transient fine sediment impacts and thresholds of stream biota.
• Timber harvest has significant potential to increase sediment yields through direct soil disturbance and stormflow erosion of streambeds and banks.	• Quantitative understanding of sources and rates of sediment yield associated with timber harvest and roads.
• In general, the most important factor in increasing stormflow and sediment yield is the design and density of trails and haul roads.	
• The geology of the Ozarks preconditions a system with dominance of gravel bedload; Quaternary events deposited gravel-rich sediments near streams where disturbance can deliver sediment rapidly.	
• Streams in the Ozarks have been much more sensitive to riparian land use changes than upland land use changes.	
• Cyclic timber harvest probably has fewer downstream effects than alternative agricultural land uses.	

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Social and Economic Sustainability in the Missouri Ozarks

Bernard J. Lewis[1]

Missouri's 14 million acres of forest land are an important part of the lives of its citizens. The State's forests provide resources for a wide variety of wood-based products and a host of recreational opportunities. Numerous species of plants and wildlife thrive in forested habitats, which also provide the ecological services that contribute to clean air, water and other elements of the natural environment. Moreover, many Missourians value their forests simply for what they are—as settings for a wide array of experiences that bring them in contact with the beauty and diversity of the forest landscape. For all of these reasons, the forests of Missouri are an important part of the *quality of life* of State residents.

This article explores the multifaceted nature of the *human dimension* of forest sustainability in Missouri. It begins with a brief look at how the idea of sustainability has evolved within the dual context of U.S. environmental policy and the field of international development, and how these policy domains have contributed to our contemporary understanding of sustainable forests and forestry in Missouri. This is followed by a demographic sketch of Missouri Ozark residents and a snapshot of the recent economic performance of Ozark counties. Attention then turns to a broad framework for understanding how sustaining the matrix of social relations and processes through which people living in the forested areas of southern Missouri interact with one another is both necessary for and depends upon sustaining the forests and ecological landscapes of the Missouri Ozarks.

ON THE IDEA OF SUSTAINING MISSOURI FORESTS

In the last decade, the concept of sustainability has become part of the rhetoric and substance of discussions on natural resource and environmental policy. Its proponents regard it as indicative of a more enlightened approach to understanding and managing natural resources in contrast to past perspectives. However, the notion of sustaining natural resources is actually over a century old and securely rooted in the profession of forestry. In the 1880s, when resource management was just getting started in the United States, it was strongly influenced by European foresters, especially Germans, who brought with them well-formed ideas about forestry. These were anchored by the idea of *sustained yield*, which focused on managing forests over the long run and maintaining their productivity. In the early days, the emphasis was on sustaining the output of timber, which also entailed protecting the viability of soils and watersheds.

Over time the scope of the concept of sustainability has been broadened in two directions from that of its earlier focus on forests. On the one hand, it has been extended in an ecological direction, recognizing that forests are a distinct kind of ecosystem that, depending on scale, is situated within an ecological hierarchy ranging from landtypes to ecoregions (see Nigh, this volume), and these too need to be sustained. On the other hand, fueled by the emergence of the notion of *sustainable development* in the 1980s, the idea of sustainability has frequently been applied to human communities, and indeed, even to societies. As a result, we find an array of sustainabilities described in the literature ranging from sustainable ecological systems, forests, and forestry to sustainable development, communities, and societies.

Despite its extensive lineage, however, sustainability as a *guiding* concept in the context of natural resource and environmental management is still an immature one. From a strictly lexical standpoint, sustainability is simply the ability to maintain something undiminished over some time period (Lele and Norgaard 1996: 355). This could apply to anything from epidemics to ecosystems. At the same time, to sustain something implies valuing it enough to put an effort into maintaining its integrity. Thus the normative force of the idea of sustainability must be derived

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primarily from the concept with which it is paired. Whether it is good, right, or appropriate to sustain something depends largely on the goodness, rightness, or appropriateness of what it is that is being sustained. In this light, as Bossel (1998: 7) observes, "the question of what is meant by sustainability is first of all a question of values and ethics." Values, in turn, are a basis for action. If we value Missouri's forests, we must strive for their sustainability.

It is certainly true that, whether people are concerned primarily about environmental amenities or the production of commodities, everyone agrees that sustaining Missouri's forests is a good thing. But defining what a sustainable forest *is* is often quite another matter. Some may view it as untouched old growth, while others may argue it is 100 acres of pine with a consistent production cycle. Nonetheless, despite its ambiguity and the need for further specification, the idea of sustainable forests serves an important symbolic function in capturing the emerging social consciousness of Missourians and others as they come to better understand the status of the natural environment as an integral part of their quality of life and, as a result, to act both individually and collectively to ensure that it remains so. As Hempel (1999: 44) observes,

> Like other transformative ideas, the concept of sustainability promises to remake the world through reflection and choice, but its potential to engage people's hopes, imagination, and sense of responsibility may depend more on strategic uses of ambiguity than on conceptual precision and clarity. Mobilizing ideas appear to be most effective when they serve as condensational symbols that defy narrow definition, encourage coalition building among diverse interests, and permit just enough comprehension and social absorption to promote convergent political acts.

In Missouri, the symbolic force of the idea of forest sustainability was evident throughout the recent series of meetings held by the Governor's Advisory Committee on Chip Mills (see Lewis, this volume). Given the task of assessing the potential impacts of two high-capacity chip mills that had set up operations in the State, the committee was comprised of individuals representing a wide range of interests, from defending private property rights and strengthening the timber industry to ensuring the protection of non-timber resources and amenities provided by Missouri forests. Given this diversity of concerns, reaching a consensus on how to deal with the chip mill issue could not be said to have been an expected outcome at the start of the committee's deliberations. Yet in attempting to define a collective goal, virtually all members agreed at the outset that their central concern was the long-term sustainability of Missouri forests. Each committee member undoubtedly had his or her distinct perspective on what a sustainable forest resource would look like, as well as the kinds of policy actions that would or should be required to make that vision a reality. But the group's consensus on the overall goal of forest sustainability provided an important initial collective glue that served to maintain group coherence and a collective sense of purpose.

Perhaps the biggest challenge related to current definitions of sustainability lies in moving from theory to practice—i.e., in making any definition operational in terms of meaningful criteria and measurable indicators. Significant efforts are underway in this regard, both those oriented toward basic ecological processes and those designed to reflect the human dimension of people's interactions with and embeddedness within ecological systems (see the introduction and appendix of this volume). In general, however, in attempting to operationalize the concept of sustainability in the area of forests and forestry, it will be prudent to heed Hempel's warning that such a task will not be easy, and that "applying sustainability criteria to everyday matters of public policy, business management, and personal consumption is fraught with conceptual and moral hazards." Indeed, identifying and avoiding such hazards is a key part of putting the idea of sustainability to work on behalf of Missouri forests.

THE EVOLVING POLICY CONTEXT FOR THE CONCEPT OF FOREST SUSTAINABILITY

It is important to recognize that our understanding and use of the concept of sustainability in forestry have evolved within the context of both U.S. environmental policy *and* international development policy, where the idea of sustainability was adopted and given substantial

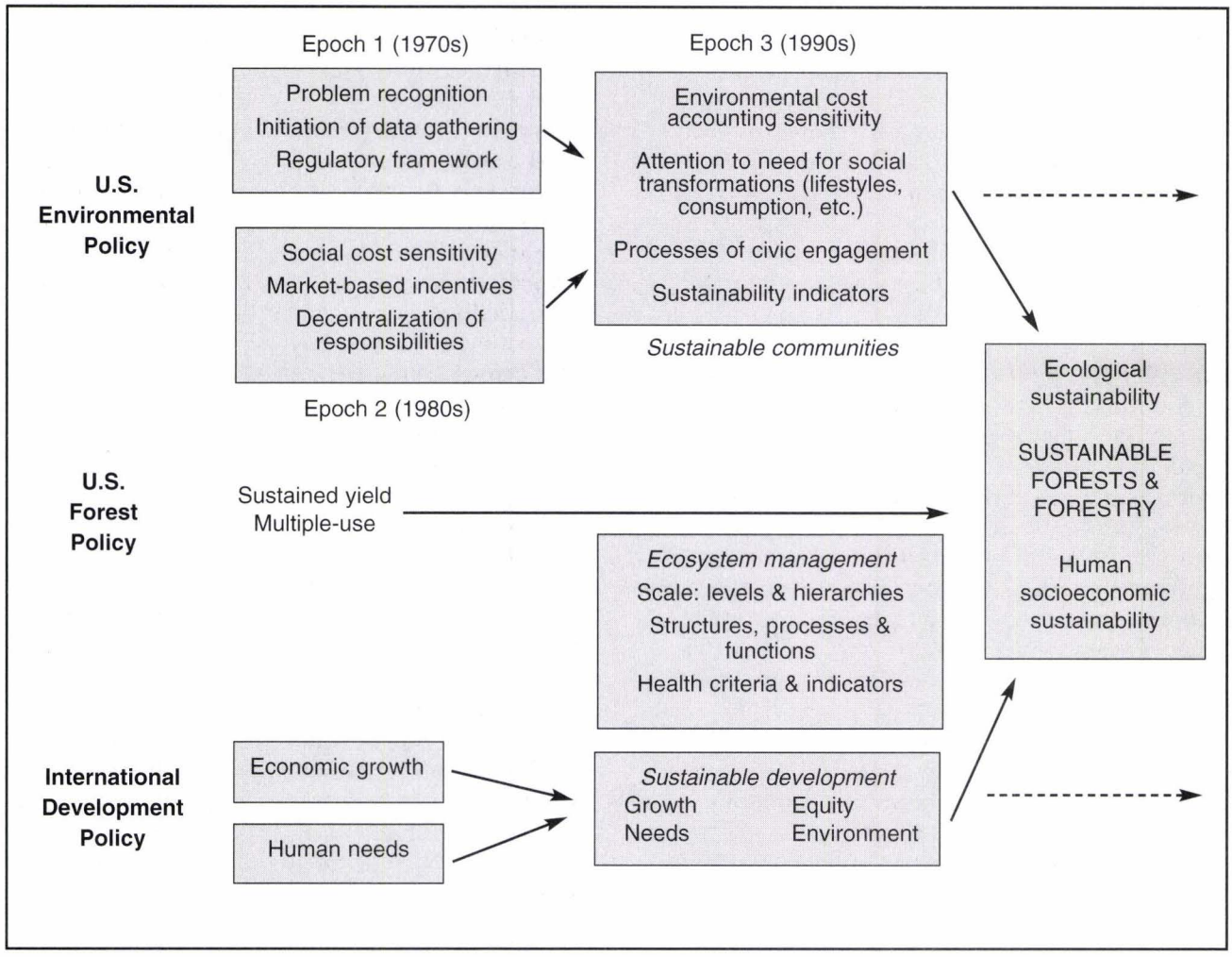

Figure 7.1—*Ideas and context of the evolution of the concept of sustainability in U.S. forest policy and management.*

impetus. These two influences, which have played critical roles in broadening the earlier scope of sustained yield in forestry, are major intellectual and practical forces that shape our understanding and use of the idea of sustainability in forestry today. Figure 7.1 depicts the coevolution of these policy domains, focusing in particular on the last three decades of the 20th century.

The concept of sustained yield served as the theoretical underpinning for federal forest management throughout the first half of the 20th century. Its status was officially sanctioned and its scope legislatively broadened in 1960 when Congress passed the Multiple-Use Sustained-Yield Act (MUSYA). This formally extended the scope of sustained yield beyond timber and water, as specified in the original 1897 organic act for Federal forestry, to include range, wildlife and recreation. Several years later, wilderness was also officially recognized as a use that was compatible with the MUSYA mandate. Sustained yield—joined via MUSYA with the idea of multiple-use—was the guiding management concept, and what was to be sustained was defined in terms of outputs, broadened from the original mandate of water and timber, and compatible with wilderness preservation.[2]

The 1960s themselves were years of social upheaval, when racial inequities, the Vietnam conflict and, through the work of Rachael Carson and others, social awareness of a historical disregard for environmental consequences of economic and social policies were at the forefront of social consciousness. Congress responded in 1969 by passing the National Environmental Policy Act (NEPA) with its broad mandate for comprehensive impact assessments and public involvement. Although the scope of NEPA pertained only to Federal agencies, it gradually spurred significant

changes across Federal and State bureaucracies in terms of their approaches to natural resource and environmental problems.

Mazmanian and Kraft (1999) view the last three decades of the 20th century as roughly delineating three "epochs" of environmental policy in the United States.[3] Each epoch embodies a dominant perspective through which environmental problems have been defined in terms of both science and values. Each also reflects the political and ideological climate that held sway at the time, building on the one that preceded it and "ultimately overshadowing (in terms of dominant ideas and focus) and overlaying it (in terms of policies and programs) but never fully replacing it" (1999: 8). As we shall consider presently, this context of evolving Federal environmental policy has also been influenced by the course of international development policy, and together they have strongly affected the contemporary understanding of the concept of sustainability in forest policy as well.

The 1970s. By the early 1970s, the environmental activism that had triggered the reactions to pollution and the surge of preservation-oriented acts by Congress in the 1960s had crystallized into a full-fledged social and political movement. While sustained yield and multiple use continued as the guiding management philosophy in forestry, the central theme of environmental policy centered on the need to 'stop the bleeding' from environmental degradation that had accumulated throughout the first two-thirds of the 20th century. Moreover, it was generally recognized that the impetus for efforts to do so would have to come from the federal government, given that most states had thus far failed to act aggressively to protect their own natural environments. Beginning with passage of the Clean Air Act on the heels of NEPA in 1970, Congress followed with the enactment of six additional major environmental laws during the course of the decade.[4] Most of these laws would be implemented through a system of command-and-control regulation centralized in a new comprehensive federal agency—the Environmental Protection Agency (EPA).

Repercussions from the surge of environmental legislation in the 1970s on Federal forest policy were reflected in the passage of the National Forest Management Act (NFMA) of 1976. While incorporating a number of environmental concerns within the context of national forest management, NFMA also reaffirmed the concept of sustained yield within a multiple-use context as the standard for managing the national forests. Nonetheless, by the end of the decade, signs were beginning to emerge that, as a guiding management criterion, sustained yield defined exclusively in terms of specific kinds of outputs for human use could not bear the weight required to anchor a management philosophy in the new environmental era.

The 1980s. At the same time, however, the EPA rapidly became almost too successful as a regulatory agency, assuming a pervasive and administratively cumbersome presence in the domain of national environmental policy. This led to a backlash against the agency and the rise of a counter-philosophy that reverberated throughout the 1980s. This shift in perspective occurred within a broadly conservative and anti-Federal government backlash that swept the country at the time. Although it was recognized that progress had been made, the eighties were a decade of frequent and severe

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[2]While MUSYA offered few, if any, specific management guidelines for implementing its mandate, it did clarify two broad points. The first was its declaration that in implementing multiple use, not every output had to be produced on every acre of forest land. Since some of the mandated outputs may be incompatible, this amounted to more of a truism than a novel management direction. Nonetheless, stating this explicitly left no room for doubt. Secondly, MUSYA also stated that other criteria in addition to maximizing economic gain could be considered when implementing multiple-use management in a given area. This was a significant recognition of the increasing importance of non-commodity forest values to the American people.

[3]These authors focus primarily on environmental policy and not on bodies of policy that have evolved in connection with specific resource outputs as delineated in MUSYA (e.g., forest or wildlife policy). For present purposes, however, this serves as an adequate policy context for the evolution of forest policy as well the concept of sustainability in natural resource policy.

[4]These included the Clean Water Act (Federal Water Pollution Control Act of 1972); the Safe Drinking Water Act of 1974; and the Resource Conservation & Recovery Act and the Toxic Substances Control Act, both enacted in 1976.

criticism directed at environmental policy, wherein legislative, administrative, and judicial assaults were launched by business and industry, property rights, and anti-environmental groups. This generated an atmosphere of reassessment, regulatory devolution and flexibility, and cost consciousness in the area of Federal environmental policy.[5] By the middle of the decade, the dominant philosophy of Federal environmental policy was that a more decentralized and collaborative approach to rulemaking and goal setting—where human economic and social costs were given greater consideration in pursuing environmental gains—was the more appropriate way to accomplish the nation's environmental agenda. In addition, such an approach should, whenever possible, be driven by incentives rather than regulations. Mazmanian and Kraft (1999: 25) conclude that this second epoch, while successful in changing ideas about how best to accomplish environmental objectives, had the actual effect of being "less a reversal in policy than a dampening of legislative zeal and policy expansion." For other forces that were emerging in the 1980s—reflecting changes in all three of the policy domains depicted in figure 7.1—would ultimately swing the pendulum back again towards the center.

One such force included the growing debate over the suitability of sustained yield as a guiding management criterion for the continually evolving fields of forest and natural resource management. As noted earlier, dissatisfaction with the concept had begun to surface in the late 1970s, not so much within the forestry profession as within others that had been brought under the sustained yield umbrella with the passage of MUSYA. The concern was not so much that sustained yield was an incorrect way to look at specific outputs, but rather that, as an element of the broader conservation philosophy of resourcism, the only way it was able to conceptualize *anything* was as an output and, even more disturbing to critics, an output whose identity depended exclusively on its usefulness to humans. To many, this was, in effect, missing the forest for the trees. For as Callicott and Mumford (1997: 34) observe,

> [E]ven if the concept of sustained yield were to be successfully operationalized, it would hardly be adequate for biological—as opposed to resource—conservation. Most species are not harvestable resources. And most of the species in danger of genetic impoverishment, local extirpation, and global extinction are not at risk because they are being overharvested, but because their habitats are being polluted and destroyed.

These concerns received support from a broader philosophy of forest and natural resource management that appeared on the horizon toward the end of the 1980s. The new focus on *ecosystem management* emphasizes the sustainability of the forest as a whole, which includes more than just outputs that are valuable for human use. If the forest as an ecosystem were sustained in terms of its key structures, functions, and processes, its ability to produce virtually all of the "outputs" desired by humans would concurrently be ensured. Thus, even as conservative political reactions to environmental policy changes of the first epoch continued through the eighties and into the nineties, an ecological perspective began to gather strength as an input to forest management philosophy that would shape understanding of the idea of forest sustainability throughout the 1990s and beyond.

Influence of international development policy. Pressure for expanding the concept of sustained yield as the guiding criterion for forest management philosophy came from other sources in addition to natural resources professions in the United States. In fact, by the 1980s the evolution and scope of the term sustainability was being influenced by another historical trend depicted in figure 7.1—that of international development policy, which had evolved on its own track since the end of the Second World War.

The post-war economic boom in the United States provided a major impetus to the belief that economic growth was the answer to the development problems of any country, rich or

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[5]This was fueled at different times by both Congress and the executive branch, from efforts to slash environmental budgets during Reagan Administration to the watershed election of 1994 in which environmental policies were a prime target of the *Contract with America*. Only in the 1996 Congressional elections, when the public had soured on the fervor of a revolution they didn't necessarily want in all its aspects, might we actually say that this transitional second period in Federal environmental policy came to a close.

poor, North or South. Rapid industrialization, which in turn would lead to improvements in standards of living, was widely regarded as the key to the development of poorer countries. However, before long this unbridled faith in economic growth began to lose some of its luster. Critical perspectives emerged both from international conservation organizations concerned about the growing negative impacts of industrialization and from forums organized by the United Nations to address the impact of development on the poor. Two decades later their efforts would result in the prominence of the concept of *sustainability* as a guiding criterion in international development policy.

A major contribution from conservation-oriented groups and researchers[6] occurred at the end of the 1970s with the publication of the *World Conservation Strategy* (WCS) by the International Union for the Conservation of Nature and Natural Resources (IUCN). It was here that the term *sustainable development* first achieved prominence in international development policy. The goal of the WCS was to integrate conservation and development "to ensure that modifications to the planet secure the survival and well-being of all people" (IUCN 1980: Section 1.2). *Conservation* is defined as managing the human use of the biosphere so that "it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" (Section 1.4). The three primary objectives for effective conservation included a) maintaining essential ecological processes and life support systems, b) preserving genetic diversity, and c) ensuring sustainable utilization of species and ecosystems. The report closed with a section entitled "Towards Sustainable Development," emphasizing that conservation and development, as opposed to being in conflict, are mutually dependent; and that only effective conservation will ensure that modification of the biosphere, which development entails, will achieve the social and economic objectives of development.

In the United Nations, meanwhile, the 1972 Conference on the Human Environment, held in Stockholm, marked the first major attempt on an international scale to bring together the world's nations to forge a constructive response to environmental problems, while ushering in a new emphasis on meeting basic human needs as part of this process. A landmark in efforts by the United Nations to forge a viable pathway for development policy occurred in 1987 with the publication of *Our Common Future*, the report of the World Commission on Environment and Develop-ment (the Bruntland Commission). From the outset the commission pledged to adopt an integrated approach to issues of environment and development, recognizing that "many forms of development erode the environmental resources on which they must be based, and environmental degradation can undermine economic development." The commission also noted the connection between consumption patterns of nations in the North and elites in the South as factors forcing the poor in the South to exhaust resources and destroy ecosystems in an effort to maintain their existence. The commission reasoned that genuinely *sustainable development* must "meet the needs of the present without compromising the ability of future generations to meet theirs" (WCED 1987: 8). The critical objectives that follow from sustainable development include reviving growth; changing the quality of growth; meeting essential needs for jobs, food, energy, water, and sanitation; ensuring a sustainable level of population; conserving and enhancing the resource base; reorienting technology and managing risk; and merging environment and economics in decisionmaking.

The Bruntland Commission succeeded in broadening the discussion of the social and political factors and institutional structures that will be necessary to achieve sustainable development. In devoting much more attention

[6]In the early 1970s, Dennis and Donella Meadows of MIT published *Limits to Growth*, which became an international, albeit controversial, bestseller. The Meadows team utilized an elaborate computer-based systems model to examine the implications of continuing exponential growth in what they viewed as five areas of global concern—population, industrialization, widespread malnutrition, depletion of nonrenewable resources, and ecological damage. Their conclusions caused an international stir: even under the most optimistic technological assumptions, if trends in these five areas continued, the limits to growth on the planet would be reached sometime within the next 100 years. Although the study was criticized on several fronts, it did have the effect of elevating international development policy as a permanent focus of world consciousness, while shaking the faith of many that its predominant focus on economic growth was the sole solution to problems that were recognized.

to these areas than did previous efforts, it effectively established *sustainable development* as the guiding concept in international development policy, a position it has maintained to the present. The commission emphasized the need for continuing economic growth and that such growth must be accompanied by institutions and practices that ensure a reasonably equitable distribution of resources and resulting benefits on both an intragenerational and intergenerational basis. It was less successful, however, in going beyond simply acknowledging that ecological limits exist and humans must live within them. Evaluations and critiques of the Bruntland Report constituted much of the debates in international development policy in the 1990s.

The 1990s and beyond. The historical pathways depicted in figure 7.1 contribute to a distinctive context for the continuing evolution of the concept of sustainable forests and forestry in the 1990s and beyond. Mazmanian and Kraft (1999) view the 1990s as marking the arrival of a third epoch in U.S. environmental policy, one that brings into sharper focus the potentiality of sustainable development and sustainable communities, with an eye towards the 21st century.[7]

The decade of the 1970s bequeathed an acknowledgment of the need for an effective regulatory framework to ensure that behavior contributing to environmental degradation is discouraged, problems are remediated, and ecological and social health are sustained.[8] Driven by policy shifts in the transitional 1980s, the consideration of social costs of environmental programs has improved, the use of economic incentives and market-based tools for resolving environmental problems has been encouraged and, to varying degrees, the command and control philosophy that underlay the establishment of a framework for Federal regulation has been decentralized by shifting more responsibilities to the states. These represent aspects of the two earlier policy approaches that have been incorporated within the perspective of *sustainable communities* that has emerged to guide U.S. environmental policy in the 1990s and beyond.

A sustainable community results from the synthesis of socioeconomic and environmental concerns towards enhancing the well-being of humans and other living and non-living systems within a particular place or bioregion. Sustainability, therefore, must be built from the bottom up via people's links to the ecological and social environments in which they forge their lives. This entails a more explicit focus on the *relationships* between quality of life in a locality and local and regional levels of population, ecological systems in which they are embedded, human consumption patterns, political participation, and commitment to interpersonal equity. As Hempel (1999: 48) defines it:

> A sustainable community is one in which economic vitality, ecological integrity, civic democracy, and social well-being are linked in complementary fashion, thereby fostering a high quality of life and a strong sense of reciprocal obligation among its members.

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[7]In discussing this third epoch, it is important to note that, unlike those that preceded it, it should not be viewed as representing a single, dominant philosophy of U.S. environmental policy in the 1990s. Rather, it combines elements of a forward-thinking movement with a variety of official policy initiatives that have been undertaken during the decade. For example, it is a better reflection of the policy direction advocated by Clinton Administration throughout the 1990s than that of the Republican Congress since 1994. Nonetheless, its significance and substantive differences from the policy direction characteristic of the 1980s led Mazmanian and Kraft to believe they are justified in calling this a third "epoch" of U.S. environmental policy.

[8]Accompanying this was a commitment to improving the quantity and quality of data, along with refinements in monitoring and measurement techniques, for assessing the status of the Nation's natural resources, including the extent and levels of different kinds of pollution. This is not to imply that all states have instituted effective regulatory programs in conforming to EPA standards and requirements, which themselves are being continually revised as better information becomes available. In fact, when the Federal regulatory framework was first established in the 1970s, the extent of information about pollution, as well as capabilities for data gathering and measurement, were quite rudimentary. Moreover, improvements in these areas have varied with the particular resource involved. Thus, for example, data on air quality have steadily improved, but even after three decades data on the health of the Nation's rivers, streams and lakes remain quite limited (U.S. Environmental Protection Agency 1996).

At the heart of the philosophy underlying sustainable communities is what Mazmanian and Kraft (1999: 16) call the hallmark of the third epoch: "the decision by growing numbers of people from all walks of life to address the transformational needs of society."

This idea of a *transformation* in thinking and lifestyles and its linkage with sustainability has also been echoed within ongoing debates in international development policy since the Bruntland report in 1987. Orr (1992: 24), for example, observes that the Bruntland Commission "hedged its bets between two versions of sustainability—technological and ecological." The former, he argues, is about the immediate tasks involved with stabilizing planetary vital signs. The latter, however, will require "the transition to a postmodern world that transcends . . . individualism, anthropocentrism, patriarchy, economism, consumerism, nationalism, and militarism."

> Ecological sustainability is the task of finding alternatives to the practices that got us in trouble in the first place; it is necessary to rethink agriculture, shelter, energy use, urban design, transportation, economics, community patterns, resource use, forestry, the importance of wilderness, and our central values.

Another important theme relative to sustainable communities surfaced as a counterbalance to the strong emphasis on market mechanisms and modes of cost accounting that dominated U.S. environmental policy in the 1980s. Critics complained that the dominant perspective failed to incorporate any measures—either benefits or costs—of environmental health and other less tangible but nonetheless real elements of what is commonly recognized as quality of life. From familiar measures of aggregate economic output (e.g., GNP) to more project-specific tools such as cost-benefit analysis, the real social and environmental costs of the depletion of natural resources, environmental damage, land use, consumption patterns, and so forth, were all too often nowhere to be found. As a response to these and other perceived shortcomings in the traditional economic paradigm, the subdiscipline of ecological economics emerged in the early 1990s (Costanza *et al.* 1997, Krishnan *et al.* 1995), re-examining such longstanding ideas as resource substitutability and developing important new concepts such as natural capital. Some of these are considered later in this article.

Yet another key focus of the sustainable communities perspective is on the kinds of processes in which citizens must become engaged if such communities are to become a reality, including how ordinary citizens may learn to draw connections between civic engagement and quality of life. While the notion of citizen involvement in shaping the affairs of state and society has a distinguished legacy in such concepts as popular sovereignty and civil society, the perspective of sustainable communities emphasizes not only the diverse array of institutional structures and informal networks through which civic engagement may be achieved, but also the importance of the ecological context within which such relationships are shaped, as well as the fundamental importance of a *sense of place* as one among many factors through which the capacity for collective action is forged.

The decade of the 1990s has also witnessed a concerted effort to establish empirical measures, or *indicators*, of sustainability. A basic tenet of sustainable communities is that, given that social interactions and practices are embedded within ecological systems that define the natural environment of localities and regions, any set of social indicators must be integrated with those that monitor ecological health in terms of the structures, processes, and functions that combine to form the landscapes of people in geographic places. Such a synthesis blends well with the philosophy of ecosystem management that has continued to gather steam since its emergence at the beginning of the 1990s. Ecologists and resource managers are beginning to define the ecological terrain at a variety of scales at which ecosystems function. Although the complexity of the task is daunting and much work remains to be done, these efforts have begun to provide more concrete and tractable foci for assessing benefits and costs of ecological services. These will be a key source of ecological indicators, whether couched in terms of sustainable communities or in terms of sustainable forests and forestry.

The development of both social and ecological indicators of forest sustainability has received a further boost from the domain of international development policy. In 1992, the United

Nations organized a conference on environment and development (UNCED) in Rio de Janeiro that resulted in non-binding conventions on climate and biodiversity, a statement of forest principles, and an action plan for sustainable development entitled *Agenda 21*. The Statement of Forest Principles led in North America to what has been called the Montreal Process, including the development of criteria and indicators for sustainable boreal and temporate forests (Woodley *et al.* 1997).

In summary, the perspective presented in figure 7.1 suggests that the contemporary status of the concept of sustainability within the domain of forest policy and management in this country is not only the result of the evolution of U.S. forest policy *per se*. Rather, it has also drawn from the domains of both Federal environmental and international development policy. Regarding the latter, one of the more striking features of the Bruntland Commission's definition of *sustainable development* in 1987 was its virtual identity with the definition of *conservation* issued by the IUCN 7 years earlier as part of its World Conservation Strategy. Although the emphasis of the two groups was different—with the WCS defining its basic objectives in environmental terms and Bruntland via a primary emphasis on economic growth and equity considerations—the desired endpoint, whether termed conservation or sustainable development, was virtually the same.

This yields an important lesson for our efforts to better understand and apply the concept of sustainable forests and forestry in Missouri and elsewhere. For whether it be couched as development or conservation, it involves concurrently sustaining ecological systems as well as people and their communities as part of an integrated whole. In this light, it is not surprising that the criteria and indicators issued by the United States Working Group for Sustainable Boreal and Temperate Forests include *both* those pertaining to ecological systems and those pertaining to human socioeconomic characteristics of individuals, groups, and communities. Such an integration of ecological and human social and economic sustainability must thus be a central feature of understanding and achieving sustainable forests and forestry, both in Missouri and elsewhere.

The rest of this article outlines a perspective of how we might begin to approach this task. Following a brief demographic and economic snapshot of Missouri Ozark residents, attention turns to a general way of envisioning the human dimension of forest sustainability in Missouri as a function of the social relationships people establish with one another and the actions they take in the context of those relationships. Key themes reflecting different dimensions of social relations are then considered in terms of their relevance for sustaining the well-being of people and forests in Missouri.

It will be important to keep in mind that the concept of scale is equally as important in understanding the social and economic dimension of forest sustainability as it is in understanding the ecological dimension. For while the focus of what follows will be on sustaining the social fabric of people living in the Missouri Ozarks (a sub-State region) as an essential ingredient of forest sustainability, Ozark residents are themselves members of broader state, regional, national, and global societies. It is evident, for example, that many Missourians living outside of rural forested areas are also vitally concerned about the status and management of Ozark forests, and they may express such concerns by visiting these areas, voting for political initiatives, and so forth. Similarly, many U.S. citizens take an interest in the management of the Nation's Federal lands, some of which are located in the Missouri Ozarks. Even more broadly, the host of social and economic forces and processes described under the rubric of globalization are directly affecting the lives of individuals in rural Missouri, and the latter's actions can actually have not only local, but global repercussions as well. Although not the principal focus of what follows, these linkages with broader social systems are an important part of the context of social life in the Missouri Ozarks.

DEMOGRAPHIC AND ECONOMIC TRENDS IN THE MISSOURI OZARKS

The following profile relies on the wealth of periodic data describing characteristics of people in places that is gathered by the U.S. Bureau of the Census. Because not all results of Census 2000 had been released at this writing, this profile also draws on the *Ozark-Ouachita Highlands Assessment* published by the USDA Forest Service in 1999 (USDA Forest Service 1999), which relied primarily on data from the 1990 Census.[9] The Ozark

Highlands area includes much of southern Missouri (except the Bootheel), the northwestern half of Arkansas, and a small portion of eastern Oklahoma. Due to the manner in which the data were organized to meet the particular objectives of the Ozark-Ouachita Assessment, we shall focus here on a group of 26 non-metropolitan counties in the Missouri Ozarks identified in this assessment as containing any land administered by the Mark Twain National Forest—to be referred to as "non-metro national forest" (NMNF) counties (identified in figure 7.2 and table 7.1).[10] These counties encompass the most extensively forested areas of the State and thus provide an adequate basis for considering characteristics of Missourians living in the rural forested landscapes of the Ozarks. About 585,000 people lived in the 26 NMNF counties in 2000, slightly more than one-tenth of the State's population.

The 2000 census revealed that Missouri witnessed its biggest population increase in five decades during the 1990s, growing by 9.3 percent to almost 5.6 million residents. The increase was the result not only of sizable natural growth (births minus deaths), but also of migration gains not seen since the final decade of the 1800s. Fully 90 percent of this net inmigration occurred outside the St. Louis and Kansas City metropolitan areas. The 93 non-metropolitan counties, in which slightly less than one-third of Missouri residents lived as of 2000, accounted for nearly 60 percent of the net inmigration to Missouri during the 1990s, after two decades of net outmigration (Office of Social and Economic Analysis [OSEDA] 2001).[11]

The dynamics underlying the State's population increase in the 1990s included a continuing expansion of big-city suburbs, a surge of people moving to the Ozarks, a halt in the exodus from several northern rural counties, and an overall growth in the Hispanic population. Of particular interest here, the immigration to the Ozarks was heavily concentrated around Springfield and the Branson area in southwest Missouri (fig. 7.2). Long a destination for tourists, the lure of relaxed retirement living, affordable housing and entertainment led to a population boom in the area during the 1990s. Christian County, for example, a metropolitan county in the Springfield area, experienced a 66 percent increase in population, from 33,000 to 54,000 residents; and two NMNF

[9]In addition to the 1990 Census of Housing and Population (U.S. Department of Commerce 1993), the Ozark-Ouachita Assessment draws upon county-level data from the *Regional Economic Information System* (REIS) (USDC Bureau of Economic Analysis 1996) and on population data from *County Population Estimates* (USDC Bureau of the Census 1997).

[10]Given that the Assessment was conducted on behalf of the three national forests in the Assessment area, the inclusion of any counties with national forest lands was important. In Missouri, the Mark Twain National Forest occupies parts of 27 counties south of the Missouri River. One of these—Christian County in southwest Missouri—is located on the outskirts of the Springfield metropolitan area; and for the Assessment this was classified as a "metropolitan national forest county." The other 26 counties were categorized as "non-metropolitan national forest (NMNF) counties." While some of these counties have as little as 1,000 acres of national forest lands within their boundaries, all have at least *some* such lands. On an overall basis, 14 percent of lands within NMNF counties in Missouri are Federally owned, while 81 percent are under private ownership. For purposes here, NMNF counties provide a fairly comprehensive set on which to base the following brief discussion. As depicted in figure 7.3, the total number of counties included in the Missouri portion of the Ozark-Ouachita Assessment includes 24 additional counties stretching from the southwest corner of the State northeast to the Missouri River. Thus, while figure 7.3 reveals information on all 51 Missouri Assessment Area counties, the discussion in the text focuses primarily on slightly more than half of those counties—i.e., the 26 NMNF counties (fig. 7.2).

[11]Two other notes of interest from the 2000 Census of Population are as follows: Among the metro areas, the greatest population growth on a percentage basis occurred in the three-county Springfield area (Greene, Christian, and Webster Counties) with a growth of 23.4 percent, followed by the Columbia area (20.5 percent) and the Joplin area (16.6 percent). During the 1990s only 17 Missouri counties, the majority in northern Missouri, suffered a *loss* of population, far less than the 53 counties that lost population during the 1980s. Moreover, among counties that did lose residents, the relative amount of loss was small, less than 3 percent in 10 of the 17 counties. In contrast, during the 1980s some counties lost as much as 20 percent of their population (OSEDA 2001).

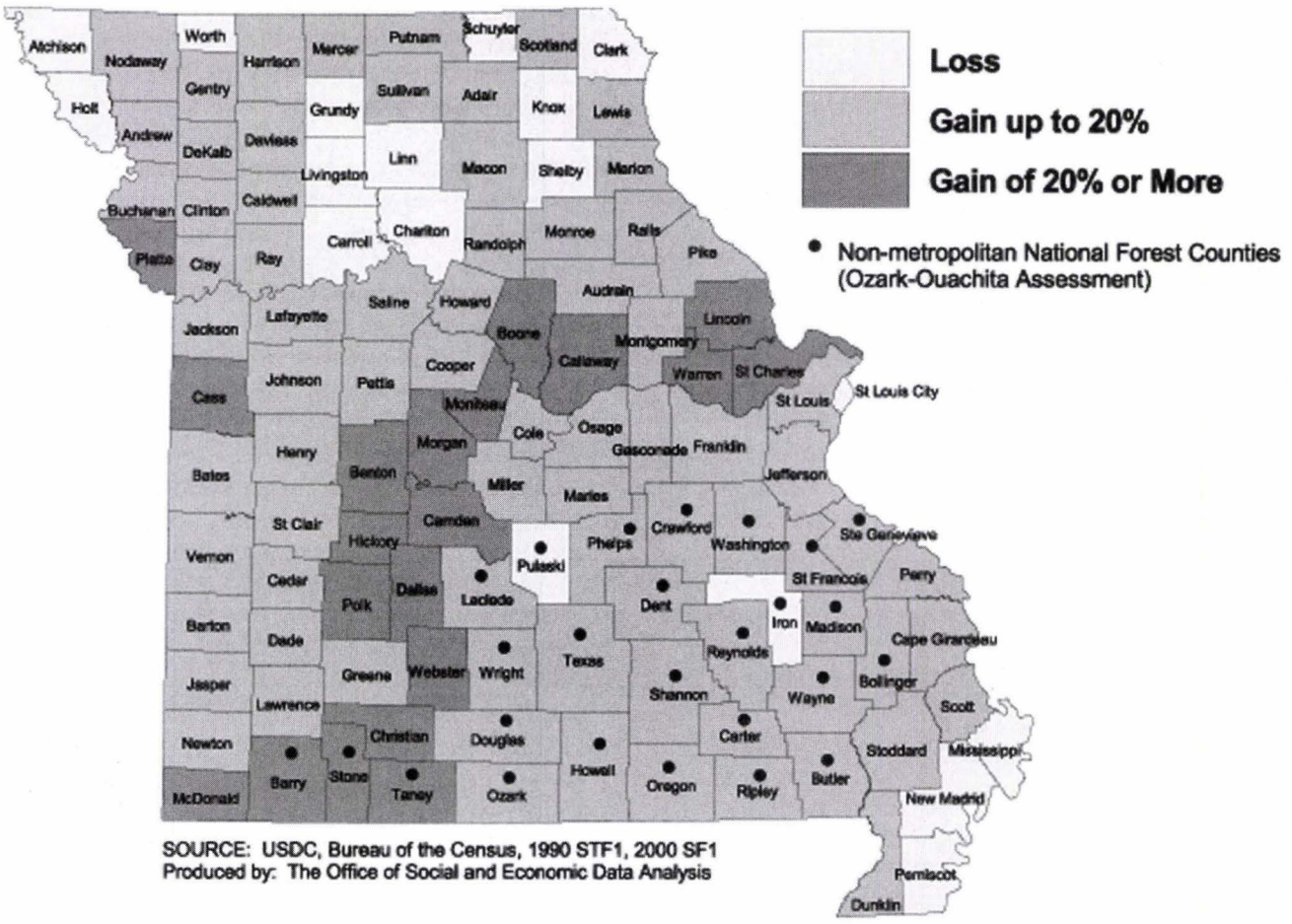


Figure 7.2—*Percent population change in Missouri counties: 1990-2000.*

counties contiguous to Christian—Stone and Taney—grew by more than 50 percent to 40,000 and 29,000 residents, respectively (table 7.1). On an overall basis, the population of the 26 NMNF counties increased by 18 percent (almost 100,000) from 1990 to 2000; and almost seven-eighths of that increase was attributed to inmigration. The only NMNF counties that declined slightly (0.3 percent) in population over the past decade were Iron and Pulaski (home of Fort Leonard Wood). In 2000, the population density of the NMNF counties averaged about 35 persons/mi^2 (table 7.1). Density levels ranged from a low of 8 persons/mi^2 in Reynolds and Shannon Counties to 123 in St. Francois County on the northeastern edge of the Ozarks. This compares, for example, with a density of 5,625 persons/mi^2 in the City of St. Louis.

It is evident that people are indeed moving to the Missouri Ozarks, with more than 85 percent of the population increase in NMNF counties over the past decade attributable to net in migration. In addition, more than three-fifths of those moving to the Ozarks are settling outside of incorporated places (city limits). Many, perhaps most, of these people are sufficiently well off in terms of income that they can afford to choose where they want to live. The forest landscape as a setting for rural residence is likely a significant factor in such choices for many individuals. As we shall see, this has important implications for potential pathways to social and economic sustainability in the Ozarks and for the sustainability of the region's forests and other natural resources.

A look at some characteristics of residents of NMNF counties in 1990 as compared with statewide numbers (table 7.2) reveals that Ozark residents are somewhat older and less ethnically diverse than Missouri residents as a whole. With respect to employment patterns, table 7.2 contains the five sectors that each accounted for at least 10 percent of total employment in the 26 NMNF Ozark counties

Table 7.1—*Land area and population characteristics for counties in the Missouri Ozarks*

COUNTY [a]	TOTAL POPULATION (2000)	LAND AREA IN SQUARE MILES	POPULATION DENSITY [b] (2000)	% CHANGE IN POPULATION (1990-2000)
MISSOURI	5,595,211	68885.9	81.2	9.3
Barry	34,010	779.1	43.7	23.5
Bollinger	12,029	620.7	19.4	13.3
Butler	40,867	697.5	58.6	5.4
Carter	5,941	507.6	11.7	7.7
Christian*	54,285	563.2	96.4	66.3
Crawford	22,804	742.5	30.7	18.9
Dent	14,927	753.5	19.8	8.9
Douglas	13,084	814.5	16.1	10.2
Howell	37,238	927.7	40.1	18.4
Iron	10,697	551.3	19.4	-0.3
Laclede	32,513	765.9	42.5	19.7
Madison	11,800	496.7	23.8	6
Oregon	10,344	791.4	13.1	9.2
Ozark	9,542	742.1	12.9	11
Phelps	39,825	672.9	59.2	13
Pulaski	41,165	547	75.3	-0.3
Reynolds	6,689	811.2	8.2	0.4
Ripley	13,509	629.5	21.5	9.8
Ste. Genevieve	17,842	502.4	35.5	11.3
St. Francois	55,641	449.5	123.8	13.8
Shannon	8,324	1003.8	8.3	9.3
Stone	28,658	463.2	61.9	50.2
Taney	39,703	632.4	62.8	55.3
Texas	23,003	1178.5	19.5	7.1
Washington	23,344	759.6	30.7	14.5
Wayne	13,259	761	17.4	14.9
Wright	17,955	682.1	26.3	7.1

[a]Included are all non-metropolitan counties in Missouri in which any acreage of the Mark Twain National Forest is located—referred to as non-metropolitan national forest (NMNF) counties. This table also includes Christian County—part of the Springfield metropolitan area. While not an NMNF county, it is the only metropolitan county in Missouri which (a) contains part of the Mark Twain National Forest and (b) falls within the geographic scope of the Ozark-Ouachita Assessment (USDA Forest Service 1999).

[b]Population density: the number of persons per square mile

Table 7.2—*Socioeconomic characteristics of residents living within Missouri Ozark counties and all Missouri residents (1990). (Source: USDA Southern Research Station 1999: 36-41)*

	Missouri Ozark counties (NMNF) [a]	State of Missouri
	(percent of population)	
A. Age:		
Less than 20:	29%	29%
20-64:	55	57
65 and older:	16	14
Change in population 65 and over (1970-90)	19	17
B. Race:		
White:	96%	87%
C. Employment by selected sector:		
Farming	10%	4%
Manufacturing	17	15
Retail trade	16	17
Services	20	26
State and local government	10	10
D. Labor force participation:		
Full-time, full year	53%	59%
Full-time, part year	25	19
Part-time, full year	8	9
Part-time, part year	14	14
Unemployment rate	8.2%	6.5%
E. Family and household income:		
Median household income ($)	$17,657	$20,832
Median family income	21,484	25,286
Per capita income	8,908	10,081
Change in per capita income (1970-90)	44%	8%
F. Poverty rate (1990):		
All persons	21%	13%
All families	16	10
Female-headed households	45	31
Related children under 18	26	17
Persons 65 and older	22	15
Change in personal poverty rates (1970-90)	-3	-1
G. Education and schooling (1990):		
Less than HS diploma	38%	26%
HS diploma or GED	36	33
Bachelor's degree or higher	9	18
High school dropout rate (age 16-19)	12.8	11.4

[a] Missouri Ozark counties: Non-metropolitan national forest (NMNF) counties: 26 counties in the Missouri Ozark Highlands with national forest lands within their boundaries.

in 1990. Not surprisingly, employment in farming was more significant in these counties than for State residents as a whole, while on a percentage basis, manufacturing employment was slightly higher and jobs in services distinctly lower for Ozark residents than for all Missourians. Slightly more than one-half of Missouri Ozark residents held year-round full-time jobs in 1990, about 6 percent less than the average for all Missourians. This was mirrored by a similar difference between those with year-round part-time jobs in the Ozarks (25 percent) and the statewide average (19 percent). The combination of all employment-related factors resulted in an unemployment rate in the Ozarks that was notably higher than the statewide average.

The median household and family income averaged about $3,000 less for those living in the Ozarks than for the State as a whole. Moreover, a cluster of five counties in the eastern Ozarks (Wayne, Carter, Ripley, Shannon, and Oregon) were among the poorest counties in the State in 1990 in median household income. Per capita income for Ozark residents was less than $9,000, or about 11 percent below that of the average Missourian. In 1990, more than one-fifth of all residents living in the Missouri Ozarks had incomes below the poverty line[12], in contrast to 13 percent of all Missouri residents. Not only did 16 percent of all Ozark families fall below this threshold (vs. 10 percent statewide), but 45 percent of female-headed households did not meet the minimum income level defined by the poverty threshold, a full 14 percent above the statewide average. Similar differences between Ozark residents and statewide averages were reflected for children under 18 and persons over 65 years of age.

In addition to income, another sharp distinction between Missouri Ozark residents and those of the rest of Missouri was evident in the area of education. It is clear that adults in Ozark counties tend to have less formal education than Missourians as a whole. In 1990, 38 percent of adult Ozark residents (25 years and older) had not graduated from high school, as opposed to slightly more than one-quarter of all adult Missourians. Only 9 percent of Ozark adults had attained a bachelor's degree or higher, half that of the statewide average. There was little, if any, correlation between dropout rates among teenagers and schooling completion rates of adults.

On an overall basis, therefore, several key indicators of socioeconomic well-being in 1990 suggest that standards of living are lower in Ozark counties than in Missouri as a whole. At the same time, changes in some of these indicators suggest that conditions are improving in a number of these counties at a faster rate than in the state as a whole. From a longer time perspective, growth in per capita income (adjusted for inflation) was in the modest range (34-65 percent) for 14 of the 26 NMNF counties from 1970 to 1990 (fig. 7.3a). More than half of these counties were keeping pace with or exceeding the statewide average (38 percent), including a number of counties in the eastern Ozarks.

Nonetheless, the above pattern has not alleviated a long-term situation characteristic of almost three-fifths of the 26 counties in the Missouri Ozarks discussed above—i.e., the persistence of low income status. The Economic Research Service defines *persistent poverty* as characteristic of counties in which persons with poverty-level incomes in the preceding year were 20 percent or more of the population in 1960, 1970, 1980, and 1990 (Cook and Mizer 1994, USDA Forest Service 1999). According to this criterion, 15 of the 26 NMNF counties in the Missouri Ozarks qualified in 1990 as persistent poverty counties (fig. 7.3b). And, as noted in the Ozark-Ouachita Assessment (USDA Forest Service 1999: 64), "Since many of the counties designated as persistent poverty counties had high rates of unemployment, relatively low levels of full-time and full-year work, relatively higher rates of self-employment, and a less-educated work force, residents of these areas could be extremely vulnerable to any job losses."

The income of Ozark residents, along with their level of education and the availability of training that allows them to contribute to a skilled labor force, form a critical part of the

[12]The Census Bureau uses a set of money income thresholds that vary by family size and composition to determine who is poor. If a family's total income is less than that family's threshold, then that family, and every individual in it, is considered poor. The poverty thresholds do not vary geographically, and they are adjusted annually for inflation. In 2000, the poverty threshold for a single person under 65 was $8,959; for a family of four, it was $17,761.

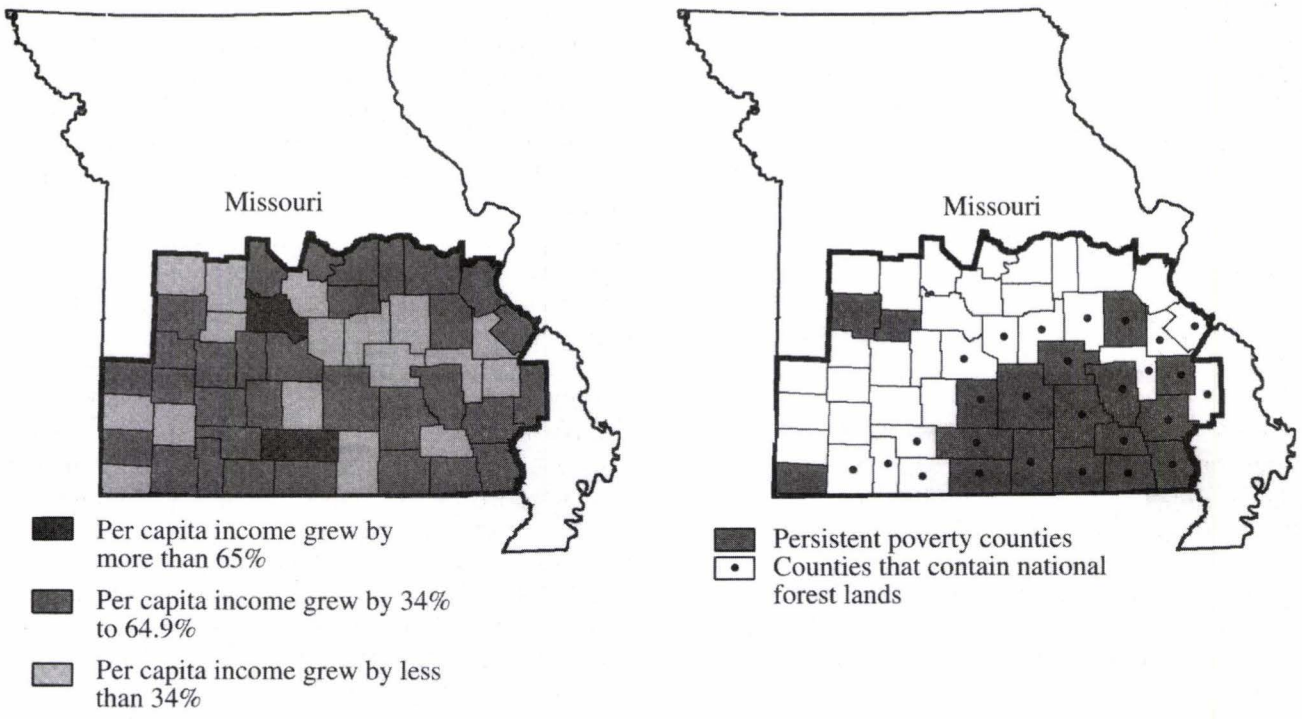

Missouri
Per capita income grew by more than 65%
Per capita income grew by 34% to 64.9%
Per capita income grew by less than 34%
a) Per capita income growth counties (1970-1990)
Missouri
Persistent poverty counties
Counties that contain national forest lands
b) Persistent poverty counties (1960-1990)

Figure 7.3—*Per capita income growth (1970-1990) and persistent poverty counties (1960-1990) among Missouri Ozark NMNF counties. Source: USDA Forest Service (1999: 62-65).*

socioeconomic fabric of the region. At the same time, the capacity for local or regional investment depends on income from a vibrant economy, which itself requires a skilled labor force. In some areas, the requisite income for public investments in education and other social programs is not available, nor is the economic and social infrastructure or skilled and diversified labor force necessary to lure investment from outside the region. This short-circuiting of the pathway to potential development can lead to persistent poverty.

Economic momentum in the Ozarks. In the Missouri Ozarks, extraction and processing of timber and minerals have traditionally played major roles in supporting the regional economy. Indeed, by virtue of their geography and resource base, most NMNF counties could be described as "natural resource dependent." Focusing on county production, employment and income, the Ozark-Ouachita Assessment identified nine NMNF counties in the eastern Ozarks as "timber-significant" and five NMNF counties as "mineral-significant" (fig. 7.4, table 7.3).[13] The Assessment also identified 19 counties in Missouri as "travel-significant" (fig. 7.4c).[14] These travel destination areas include three clusters of counties in the most scenic parts of the State—the southwestern Ozarks around Branson, the eastern Ozarks, and the Lake of the Ozarks. Eleven of these 19 counties are NMNF counties (Laclede County is the only NMNF county in the Lake of the Ozarks area). In addition, three NMNF counties—Ozark, Taney, and Stone in southwest

[13]In the Ozark-Ouachita Assessment, counties were defined as "significant" (relative to the economic importance of resource-related industries—timber, mining, and travel) if they had at least twice the average percentage of industrial output, employment, and/or employee compensation that those industries displayed for the 3-state, 107-county assessment area as a whole (USDA Forest Service 1999: 101). For purposes here, comparing county industry output figures with reference to those of the respective industries for the State of Missouri as a whole would have been more desirable, but statewide comparisons were not provided in the assessment.

[14]In the Ozark-Ouachita Assessment, no differentiation was made among the wide variety of purposes for travel (e.g., business, recreation, family visits). It was noted, however, that many trips are taken for multiple purposes, as when travelers on business trips visit relatives or engage in recreational activities as well.

Missouri—have been identified by the U.S. Economic Research Service as "retirement destination" counties on the basis of the large number of retirees who have migrated there.

Table 7.3 uses data from Census 2000 and other sources in depicting trends in income and employment from 1990 to 1999 for the 26 NMNF counties in the Missouri Ozarks (metropolitan Christian County is also included). Counties identified as significant with respect to timber, minerals, travel, and retirement are also indicated, as is a measure of overall *economic momentum* for NMNF counties as of June 2001. This is a composite index of percentage changes in population, employment, and personal income over a given time period, which in table 7.3 is from 1995 to 2001 (Office of Research, MO Department of Economic Development 2001). For an individual county, the index measures economic momentum in that county relative to that of the State as a whole (which ranked 31st out of 50 states in year 2000).

On a statewide basis, 56 of Missouri's 115 counties (48 percent) had positive economic momentum ratings (i.e., an index value greater than zero) for the period from 1995 to 2001, while 59 counties (plus St. Louis City) experienced sluggish growth (i.e., an index value less than zero). For the 26 NMNF counties plus Christian County in table 7.3, which make up slightly less than a quarter of all counties in the State, 12 (40 percent) displayed positive economic momentum index values. Christian County, south of Springfield, far exceeded any other county in the State with a momentum index of 2.92, and Taney County, home of Branson, placed second in this group (and third in the State) with an index of 1.87. The only other NMNF county with a momentum index exceeding 1.0 was Laclede County on the edge of the Lake of the Ozarks region. Both Laclede and Taney are travel-significant counties, with the latter being an important retirement destination as well.

From a statewide perspective, table 7.3 provides evidence that Christian and Taney Counties are the catalyst for an area of economic activity stretching from the Lake of the Ozarks to Branson in which recreation, tourism, and quality of life linked to an aesthetically pleasing natural environment are important driving forces. At the same time, in 1996, more than four-fifths of industrial output and employment in Taney County was related to the travel industry, while these figures for Stone County exceeded 50 percent. This reveals that these counties in the Branson area are clearly travel-*dependent*. Employment in the travel industry tends to exhibit strong seasonal fluctuations, as exemplified by unemployment rates of 17 and 13 percent for Stone and Taney Counties, respectively, in March 2001, the highest for any NMNF counties.[15] In 1993, for example, more than half of the work force in Taney County was employed in seasonal or part-time jobs, suggesting that many workers (and potential workers) could be struggling to make ends meet. Thus, even in areas of high annual economic growth, the structure of the local economy can be as important a factor in the well-being of local residents as are the overall levels of output production. Even the added economic benefits of counties being selected as retirement destinations have risks associated with them as well. For many residents in these counties (Taney, Stone, and Ozark) are much more vulnerable to large fluctuations in interest rates or the stock market and to significant changes in the social security system than those who have a smaller proportion of their assets invested in or dependent upon these mechanisms. This vulnerability could extend not only to retirees but also to employees in the large retail trade and service sectors in these economies (USDA Forest Service 1999: 65).

At the same time, it is interesting to note that for Laclede County, the other NMNF county with a momentum index greater than 1.0, only about 10 and 12 percent of output and employment, respectively, were accounted for by the travel industry in 1996. For Christian County, a metropolitan national forest county and the clear State leader in economic momentum, total output and employment were not related to any of the three resource-based industries (nor retirement) to an extent

[15]To account for relatively large fluctuations in unemployment in such industries, economists traditionally use *seasonally adjusted* employment figures to more accurately reflect the overall employment and income patterns in an area. The figures for economic momentum in table 7.3 are *not* seasonally adjusted, making them somewhat higher in March 2001 for Taney and Stone Counties than they would otherwise be had such an adjustment been applied.

Table 7.3—*Trends in per capita income (1990-99) and unemployment (1990-2001) and index of economic momentum for Missouri Ozark counties. Source: Office of Research, MO Department of Economic Development, Office of Social & Economic Data Analysis (OSEDA), University of Missouri-Columbia.*

STATE / COUNTY	RESOURCE-SIGNIFICANT COUNTIES	PER CAPITA INCOME ($) 1990	PER CAPITA INCOME ($) 1999	P.C. INCOME % CHANGE (1990-1999)	UNEMPLOYMENT RATE (%) 1990	1995	UNEMPLOYMENT RATE (%) March 2001	ECONOMIC MOMENTUM June 2001
MISSOURI		17,751	26,404	48.7	5.8	4.8	3.7	
Barry	Minerals	12,576	18,739	49	4.5	7.7	3.6	0.29
Bollinger		10,705	15,311	43	8.7	6.4	6.3	0.28
Butler	Timber	12,674	21,590	70.3	7.5	6.5	5.4	-0.32
Carter	Timber / Travel	10,864	15,652	44.1	10.3	8.4	5.9	-0.64
Christian*		14,012	20,309	44.9	5.6	3.8	3.7	2.92
Crawford	Travel	12,564	18,373	46.2	8.8	6.8	5.5	-0.19
Dent	Travel	12,293	18,900	53.7	7.2	6.5	7.5	-0.33
Douglas	Travel	9,577	15,393	60.7	7.1	9.6	8.5	-0.11
Howell		11,670	18,420	57.8	6.1	6.7	4.5	0.39
Iron	Minerals	11,224	16,619	48.1	10.1	9.8	7.4	-0.73
Laclede	Travel	12,678	19,473	53.6	11.2	7.4	5.1	1.06
Madison	Timber	11,790	17,498	48.4	9.4	8.9	6.9	-0.35
Oregon	Timber	10,119	14,390	47.5	5.5	6.3	4	-0.05
Ozark	Travel / Retirement	10,862	14,563	34.1	6.7	6.2	5.2	-0.44
Phelps		13,854	21,041	51.9	6.0	3.9	2.9	0.57
Pulaski		14,254	23,039	61.6	10.0	7.2	5.8	0.68
Reynolds	Timber/Minerals/Travel	10,785	16,395	52	7.3	5.6	8.8	-1.51
Ripley	Timber / Minerals	9,635	14,199	47.4	7.3	9.6	6.3	-0.09
Ste. Genevieve	Timber / Minerals	13,852	21,152	52.7	5.6	5.1	4.5	-0.05
St. Francois		12,261	18,215	48.6	10.0	7.7	6.4	0.26
Shannon	Timber / Travel	9,605	14,898	55.1	9.9	7.1	7.2	-0.17
Stone	Travel / Retirement	14,870	21,660	45.7	9.3	10.8	17	0.56
Taney	Travel / Retirement	14,549	22,035	51.5	10.4	8.6	13.3	1.87
Texas		10,567	15,166	43.5	9.1	9.6	5.5	-0.2
Washington		10,548	15,883	50.6	13.2	10	7.4	0.57
Wayne	Timber / Travel	10,235	15,137	47.9	11.7	18	9.2	0.11
Wright		10,720	14,410	34.4	9.3	12.4	8.2	-0.8

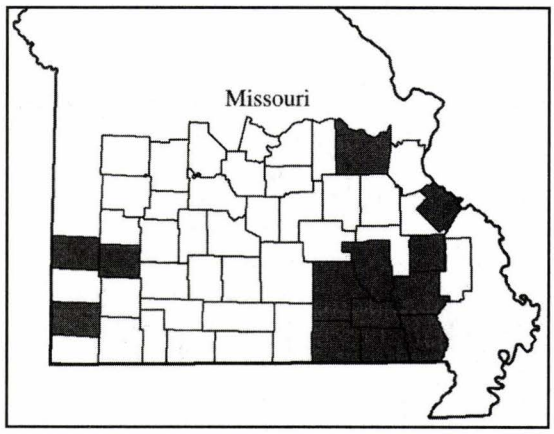
economic momentum : an index calculated as a composite of percentage changes in personal income, population, and employment (MoDED)

An index value of 0.0 indicates the focal county experienced economic growth at a rate equivalent to the statewide average.

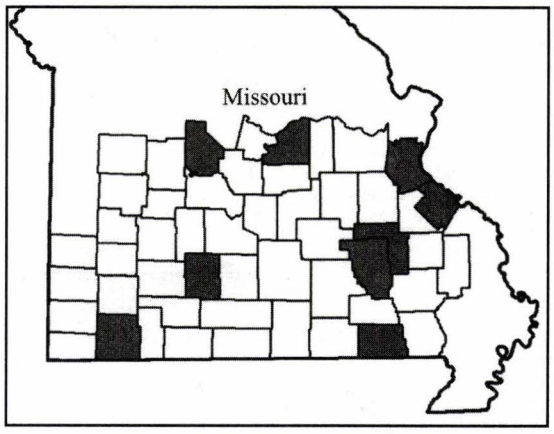
An index value greater than 0.0 indicates a growth rate in excess of the statewide average, while a value less than 0.0 indicates sluggish growth that lags behind the statewide average

resource-significant : a) timber / minerals / travel : counties in which the forest products, minerals, and/or travel industry had an average percent of total output, employment, and/or employee compensation that was at least twice the average for the overall 107-county Ozaark-Ouachita Assessment Area; b) retirement-destination counties identified by the Economic Research Service (Source: USDA Forest Service, Southern Research Station 1999:65-104-115.).

a) Timber-significant counties



b) Mineral-significant counties



c) Travel-significant counties

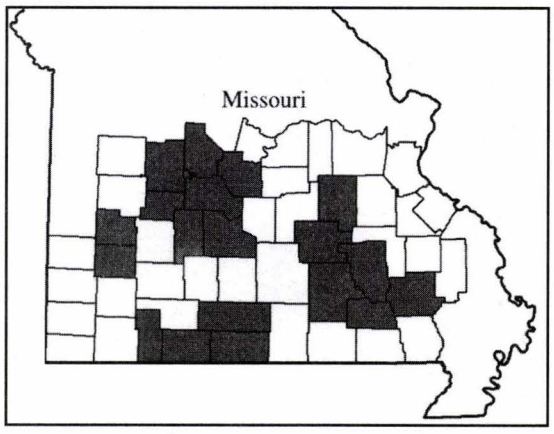


Figure 7.4—*Missouri Ozark counties identified as significant for timber, minerals, and travel. Source: USDA Forest Service (1999a: 104-115).*

meriting its designation as significant in those areas. This, of course, does not mean that one or more of these industries may not be vitally important to these counties. Rather, it suggests that this highly specialized sense of the term "significant" in terms of percentage of a county's output and employment devoted to certain industries is not in itself either a prerequisite for or a guarantee of strong economic performance or, ultimately, economic sustainability. In short, when "significant" becomes "dependent," a local or regional economy can become vulnerable to broader economic forces that influence the status of the resource in question.

It is evident from table 7.3 that the eastern Ozarks region is struggling relative to many other NMNF counties. Most counties in this region are significant with respect to timber, travel, or, to a lesser extent, mineral resources (fig. 7.4). When this relationship of resource significant counties to economic growth and momentum is summarized for all NMNF counties, the following pattern emerges. Eighteen of the twenty-six NMNF counties were identified by the Ozark-Ouachita Assessment as significant with respect to timber, minerals, travel and/or retirement (the former two for 1993, the latter for 1996). As of June 2001, only 1 of 11 timber-significant counties displayed an economic momentum index greater than 0; none of the 3 eastern Ozark minerals-dependent counties did so (Barry Co. in southwestern Missouri did have an index of +0.29); and 4 of the 18 travel-significant NMNF counties had an index greater than 0. Moreover, Reynolds County in the eastern Ozarks—alone among the 26 counties in being identified as significant in all three of the primary resource domains (timber, minerals, and travel)—displayed the fourth-lowest index for economic momentum (-1.51) among the 115 counties in the State. At the same time, of the other 8 NMNF counties that were not resource-significant for any of the above resources, 6 had positive economic momentum ratings. This again points toward the potential benefits of economic diversification, providing further support for the idea that sustainability involves more than simply the importance of a particular resource to the local economy (in terms of output and employment), but the structure and diversity of that economy as well.

Finally, although the majority of NMNF counties continue to struggle to keep pace with statewide and national patterns of economic momentum, there are some positive signs that headway is being made. Table 7.3 displays per capita income trends for the above counties from 1990 to 1999. For half of NMNF counties, per capita income increased at a rate greater than or equal to the statewide average during this period, while for another nine counties increases were within 3 percent of that average. Butler County on the edge of the eastern Ozarks led all NMNF counties with an impressive income increase of 70 percent, while Pulaski and Douglas Counties saw their per capita incomes grow by more than 60 percent, well exceeding the statewide average of 48.7 percent. To some extent this continues a pattern reflected in figure 7.3a.

With respect to income flowing into the region from elsewhere, it is also noteworthy that a significant source of income for Ozark residents is in the form of transfer payments. Often called entitlements, these include such programs as Social Security, Medicare, Medicaid, unemployment compensation, and so on. In NMNF counties, more than 85 percent of transfer payments are associated with health care or Social Security. As a percentage of total personal income, such payments tend to be noticeably higher for residents of NMNF counties when compared to the average Missourian. In 1999, for example, only Pulaski County, home of Fort Leonard Wood, was less than the State average in this regard (12.7 percent vs. 14.5 percent of total personal income). Eight counties had a level more than twice the State average (OSEDA 2001). While transfer payments, and the inherent degree of uncertainty associated with most programs tied strictly to Federal spending, do not provide the solid potential for long-term economic sustainability that investments from within the economy can stimulate, as a form of income injected into the regional economy, their impact can be significant. For most of the Missouri Ozarks, the health care system, supported to a large degree through transfer payments from the Federal government, is the most important sector in the region in terms of the combination of direct and indirect economic impacts.

As the landscape within which these processes transpire, the forests of the Missouri Ozarks are profoundly affected by the socioeconomic status of the people who live there. It has often been observed that people who are struggling to make ends meet have relatively little time or energy to devote to such esoteric concerns as sustaining the ecological integrity of their forest and natural environment. Moreover, their immediate concerns may understandably foster short-term and predominantly instrumental perspectives towards such matters, the antithesis of the idea of sustainability. It is only when some of the socioeconomic difficulties outlined above can be transformed into a situation in which basic needs are met and opportunities for individual self-improvement are available that a sustainable integration of socioeconomic and ecological sustainability may be ensured. Toward this end, our attention now turns to key dimensions of social life within which the challenging task of sustaining forests and other natural resources in the Missouri Ozarks will necessarily be played out.

KEY DIMENSIONS OF SOCIAL AND ECONOMIC SUSTAINABILITY

One way to envision the social fabric of a group of people living in a locality or region such as the Missouri Ozarks is in terms of the dynamics of social *relations* among its members (fig. 7.5a) (Alexander 1983). For

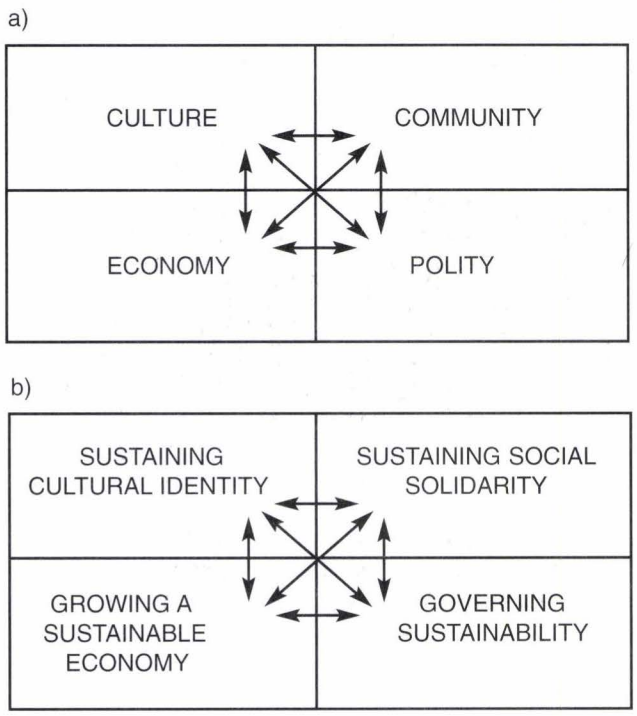


Figure 7.5—*Key dimensions of social relations among people in a locality, region, or society as a lens for understanding social and economic sustainability.*

when people interact with one another on an ongoing basis, they form relationships that shape the distinct character of social life, which in turn both enables and constrains individual actions in various ways. Although defining the boundaries or rules of inclusion for members of such a group or *social system* is not always an easy task, here we shall focus primarily on a town or community and its immediate surroundings (viz., a "local area") in the Missouri Ozarks.

In such a locality, people interact with one another in producing goods and services they consume themselves or trade with those elsewhere to obtain income and, they hope, some degree of wealth. There is, in effect, an **economic** dimension to social life in the community. Moreover, through competition and entrepreneurship, in combination with a wide array of other social factors and individual characteristics, area residents may find themselves at the center or on the periphery of activities that constitute the *local economy.*

People in a local area or community will also be more or less involved in defining goals for themselves *as* a group, in making decisions not strictly out of self-interest, but also by way of recognizing that collective as well as individual actions are required to sustain the things they value. Moreover, not everyone will always agree on the best way in which some public problem or opportunity ought to be addressed. In short, there is a **political** dimension to social life in the local area as well.

At the same time, the relationships that people form with one another, because they live together in the same place and in many cases share similar values and interests, may engender a sense of group cohesion augmented to a greater or lesser degree by individuals' particular personal traits. In short, there will be a more or less pronounced dimension of **community or social solidarity**,[16] often reflected in a shared sense of place, among residents in the local area. Perhaps it may remain latent or untapped, but it is surely an important dimension of social life.

Finally, people living in a particular place will perceive, understand, and value the world in a distinctive way. Over time, a variety of beliefs, values, and modes of expression may become shared and even passed on from generation to generation. In the process, a more or less coherent and viable local **culture** may evolve. As the young of each generation are socialized into the distinctive ways of life of their parents, this pattern of seeing and valuing the world may become taken for granted as the background to everyday life. In rural areas such as the Missouri Ozarks, the significance of the forest landscape will undoubtedly be interpreted through such a lens as part of the local culture.[17] At the same time, such a culture itself rests, however uneasily, within broader societies comprising the Midwest, the Nation, and in the present age of globalization, even the world. Given the rapid transmission of information and the broad array of economic interdependencies in contemporary life, cultural identities tied to distinctive peoples and places such as the Ozarks are becoming more difficult to sustain.

All of the above suggests that social and economic sustainability, if it is to become or remain a reality for people of the Missouri Ozarks, will emerge through the entire multidimensional complex of social relations they form with one another and others outside the region (fig. 7.5a). And all such relations originate and develop within a natural setting that is itself a central component of people's daily experiences. This suggests a broad yet arguably accurate answer to the basic question of *what it is that ought to be sustained* when we speak of social and economic sustainability. For it is people's simultaneous experiences of one another and their natural environment that shape the variety of life chances and opportunities that together constitute the *quality of life* in the Missouri

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[16]The concept of *community* employed in the context of social relations does not refer to a concrete town or community in a specific geographic location, but rather to the sense of community or *social solidarity* that may or may not evolve as people form social relations with one another. This in turn may range from strong to weak, depending on how such relations evolve.

[17]Not all of a culture is being accessed within the web of social relations among members of a society at a given point in time. In this light, a cultural tradition transcends a society at a particular moment, but as depicted in figure 7.5, at any given time there is always a cultural dimension to the pattern of social relations of people living in the area.

Ozarks. Creating a sustainable quality of life in rural forested areas in Missouri will depend on how effectively Ozark residents are able to maintain their cultural identity, foster sustainable economic relations, retain the power and means to guide their own efforts at achieving collectively defined goals, and create solidarity and a sense of place cultivated in ongoing social relationships anchored in a shared lifestyle (fig. 7.5b). These reflect the key dimensions within which group or community life unfolds. That life will, in turn, undoubtedly be affected by patterns of immigration and other demographic changes discussed earlier. At the same time, people's social relationships will have material manifestations or be played out through interactions with the natural environment, thus directly affecting the sustainability of Ozark forests and other natural resources. As an integral part of the lifeworld of Ozark residents, the forest is interpreted culturally in terms of a host of meanings; it is utilized economically for many resources; it is the focus of goals and decisions taken collectively by local people in terms of their vision of the public interest; and it is the setting of numerous and diverse community experiences.

Figure 7.6 contains some of the important elements of a multidimensional pathway to economic and social sustainability for a rural forested region such as the Missouri Ozarks and its individual communities. While neither exhaustive nor representative of what every community can actually accomplish on its own, it highlights some of the considerations that need to be addressed in answering two key questions relevant to the possibility of sustaining the quality of life in a locality: "what makes people want to live there?" and, with respect to the economy, "what makes businesses want to locate there?" The rest of this article examines some of the many aspects through which these dimensions of social life are integral to achieving the broad goals of economic and social sustainability.

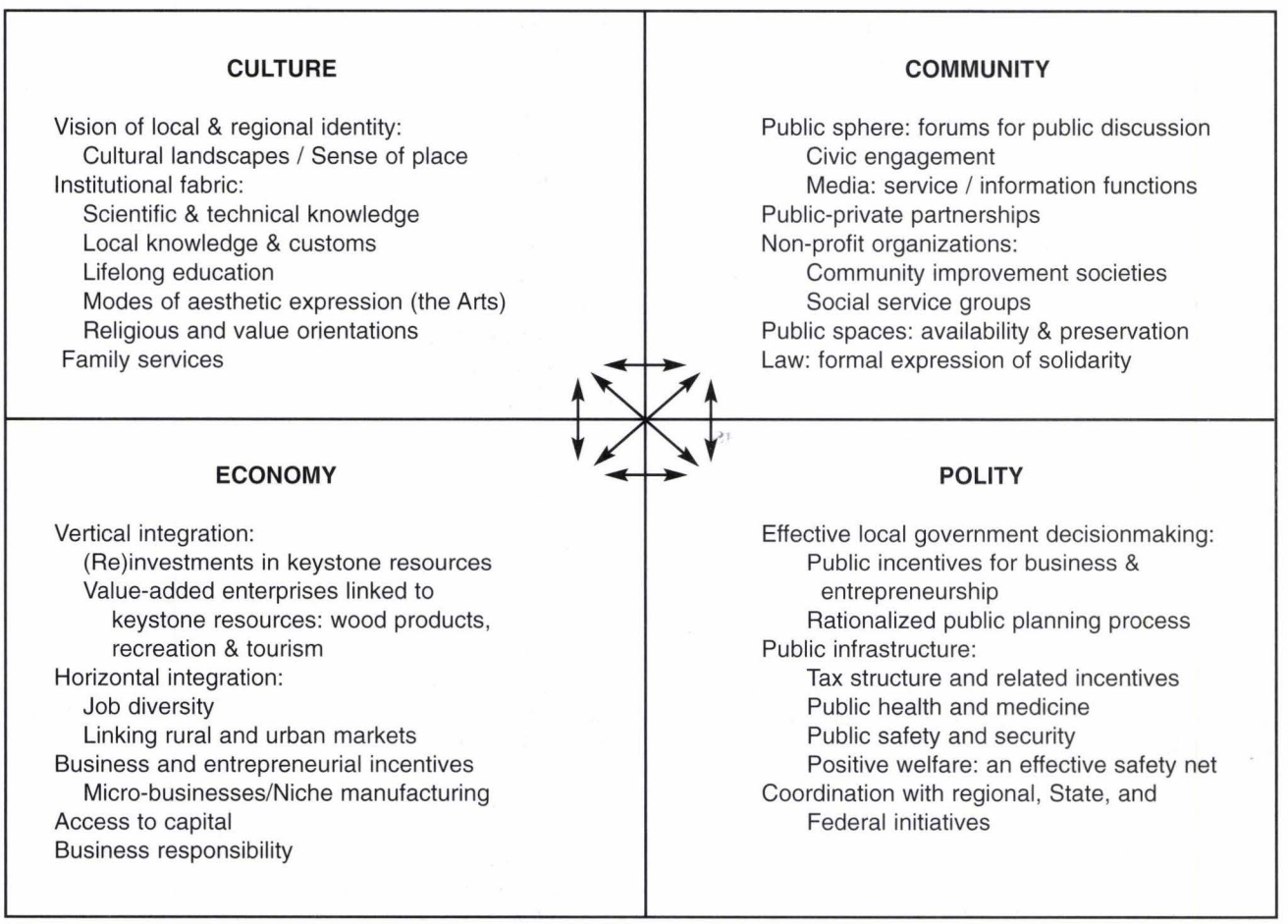

Figure 7.6—*Elements of a pathway to social and economic sustainability for rural areas and communities in the Missouri Ozarks.*

Economic relations are a principal driving force through which both basic necessities and the more refined natural and social amenities that constitute a desirable quality of life may be created and sustained. In the most general sense, an *economy* refers to the set of processes through which factors of production are mobilized through employment and investment and committed to the production of goods and services that are distributed to consumers. From the perspective of a society or community, the ultimate output of the economy may be viewed as wealth or income.

In traditional welfare economics, sustainability (or sustainable development) has been viewed in terms of the responsibility of present generations to act in ways that leave to the future the option or capacity to be as well off as we are. As Holland (1999: 48) observes, "we should aim to replace current practices and institutions with ones that promise to maintain a certain level of human welfare indefinitely." Thus it is *non-declining human welfare* passed on to future generations that is at the center of an economic view of sustainability. This, in turn, requires a healthy system of basic economic processes—production, consumption, investment, trade—and outcomes—sales, employment, income—that may enable such a level of societal welfare to be attained.

Natural capital and keystone resources. With respect to the key process of investment in resource-dependent local economies, the natural resource base may be viewed as an important type of capital. In economics, *capital* has traditionally been defined as the manufactured (i.e., humanmade) *means* of production, such as buildings, machinery, tools, and so on, or the finances to acquire such resources. Oriented to future productive capacity rather than present output or consumption, capital is the engine of investment in an economy. In the last decade, the scope of the concept of capital has been extended to include not only *humanmade* (or financial) entities, but also certain elements, relationships, or processes of nature that represent irreplaceable resources. It is argued that such resources comprise a distinct and valuable form of capital—*natural capital.*[18]

Prugh (1995: 51) observes that what natural and manufactured capital have in common is that "they both conform to the working definition of capital as a stock (collection, aggregate) of something that produces a flow (a periodic yield) of valuable goods or services." Capital investments are treated differently than current expenses, recognizing their long-term investment-oriented focus. At the same time, it is well recognized that consuming the stock as well as the flows (e.g., the goose as well as the golden eggs) leads to declines in both present and future wealth. Thus, keeping the capital stock intact is the minimum safe condition for sustaining any economic enterprise over time. Economic sustainability involves passing on to future generations an appropriate level of capital assets—manufactured and natural—with which those in the future may achieve at least the level of human welfare that we in the present generation have.[19]

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[18]Prugh (1995: 52-53) outlines a taxonomy of capital that includes three basic categories: natural, manufactured (humanmade), and human capital. The latter is defined as "the collective knowledge, skills and culture of the species." He also defines a fourth, a hybrid category called *cultivated natural capital*, which combines features of natural and manufactured capital. This includes "all agricultural and aquatic systems, such as tree farms, sod farms, fish ponds, and greenhouse nurseries. The components of these systems are not manufactured by humans, but they are not entirely natural either." It should also be noted that human capital is often discussed in the literature via the term social capital.

[19]This endowment to the future could be described as simply some necessary total amount of capital passed on, without worrying about the mix of manufactured and natural capital. In effect, the two kinds of capital would then be viewed as substitutable for one another, a perspective that in recent debates has been referred to as ***weak sustainability***. However, if natural capital is identified on the premise that certain natural resources are essential ecological assets or processes that serve key functions as part of broader ecosystems, these assets would have to be sustained intact to even allow for sustaining human welfare. Thus, they are inappropriate for averaging in with other kinds of capital assets—i.e., manufactured capital. They then will have to be sustained and protected as a physical stock, and a certain base level of physical stock would have to be passed on to future generations (along with other humanmade capital). In this latter perspective, referred to as ***strong sustainability***, natural capital and manufactured capital are essentially complements, as opposed to substitutes (see Daly and Cobb 1989).

Such an endowment will require an accurate method of accounting for natural capital. While it is relatively unproblematic to estimate the value of most manufactured capital in terms of market prices and production costs, it is often difficult to put a dollar value on many ecological processes and functions, outputs of ecological systems, and the like, much less to compare the value of these natural capital assets over time via discounting and net present valuation techniques. It may, therefore, be more worthwhile to measure natural capital via inventories that identify levels of physical stock or the presence of certain ecological processes—recognizing that there are critical limits below which these assets cannot be depleted without dramatic ramifications for sustainability—as opposed to trying to put a dollar value on everything.

Such a *physical stock* approach to accounting for natural capital still preserves the many possibilities for economic and social value of natural resources as part of the economy of the local area. As Norton (1999: 146) describes, some resources such as timber or salmon runs may be seen as *keystone resources* in economic and community development in that "maintenance of jobs in the region, in extraction, in transportation, in tourism, and in manufacturing, all depend upon protecting these resources." If they are overexploited and exhausted, their loss will reverberate throughout the economy (as, e.g., when an employer closes a local mill). In this perspective, keystone resources are not interchangeable with other forms of capital and "form the basis of place-based regional development. Their loss erodes the distinctiveness of the landscape and the diversity of available habitats in the region." A physical stock approach to accounting for natural capital will include both keystone resources and the key functions and processes of the ecological systems from which they are derived.

The traditional economic model of resource-dependent communities. Before discussing further implications of this view of natural capital and keystone resources, let us review the traditional understanding of how a strong regional economy might be developed and sustained in a rural forested area such as the Missouri Ozarks. Power (1995: 236-237) outlines the traditional economic theory known as the *economic base model.* This begins with the premise that for people to live satisfactorily in any locality, they must have income that allows them to acquire from the broader, external economy those items that they cannot easily produce themselves. They can obtain such income through the successful marketing of products they *can* produce and export from their locality or region. Thus it is "the income from their exports that allows them to pay for the imports that make life viable in that particular location," and it is this "export-oriented economic activity that is considered to be the basic driving force in the local economy, while locally oriented economic activity is secondary."

The dynamic of this causal relationship is described in terms of an *income* or *employment multiplier.* Income earned from exports is spent and re-spent locally, in the process providing local employment and income through locally oriented economic activities. Thus on an overall basis, it is export-oriented activities that both directly and indirectly drive all other economic activity in the region; and for an area such as the Missouri Ozarks, these activities have in the past primarily involved the extraction of timber and minerals. This overall process can be depicted (in a very simplified version of the economic base model) as the *extractive model of the local economy* (fig. 7.7a). For a resource-dependent region like the Missouri Ozarks, this model has traditionally been regarded as charting a viable pathway to economic sustainability. The underlying strategy accompanying this process has generally involved a focus on maximizing economic growth, which is often measured in terms of the total output of production (e.g., gross national or regional product), although the shortcomings of these and related measures have been widely recognized. From the perspective of welfare economics, maximizing growth will translate into the non-declining human welfare to be passed on to future generations. Growth is maximized by continued investment and re-investment of profits in productive enterprises generating the highest return, and trade helps to channel such investments to areas (geographic regions) that have a competitive advantage in terms of resources, labor force, and so forth, thereby enabling such inputs to be utilized most efficiently.

One obvious requisite for sustaining such regional economic activity is that the exporting industries of timber and mining need to be continually supported, given their role as the

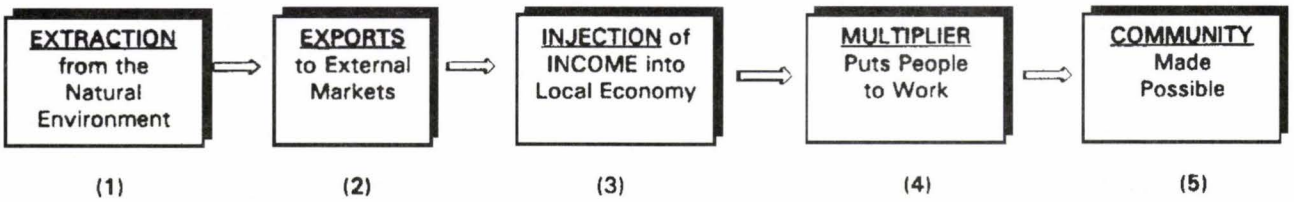

Figure 7.7a—*The extractive model of the local economy. (Source: Power 1995: 237).*

driving force or *economic base* of the local economy. This requires that a significant portion of the profits generated by these extractive enterprises be re-invested in those industries and the resources that support them. However, what happened historically with respect to Ozark forests (see Flader, this volume) was that such necessary re-investments in the forest resource and timber industry did not occur, the resource was exploited and not replenished, and a boom period of extraction was followed by a period of economic decline from which many areas of the Ozarks have yet to fully recover. Firms involved in boom-and-bust scenarios frequently are not especially concerned about sustaining the long-term viability of the local economy. They are there to extract the resource until it becomes too expensive to do so, and then move on.

In the Ozarks, extraction and processing of timber and minerals have for most of the past century been viewed as the dominant source of income flowing into the regional economy—i.e., the principal engine of economic growth. Given the long history of these activities in the region, this has created a shared vision of how Ozark residents "make their living." Such a vision has in effect become part of the local culture. However, when the character of the local economy begins to change, there is often a substantial lag in cultural adjustment; and one of the last things to be revised is the collective understanding of what drives the local economy.

A sustainable economic pathway. Having situated the forests and other ecological features and processes of the Missouri Ozarks as keystone resources relative to the economy, let us consider two broad axes or dimensions through which a local economy may become sustainable. In the extractive model (fig. 7.7a), the economic base of exporting firms in an area allows the local economy to expand outward by establishing linkages with broader regional, national, and even international economies. We shall refer to this creation and maintenance of external linkages to broader economies as *horizontal integration* of the local economy. When external markets for local products are formed or strengthened, new income is injected into the local economy, thereby enhancing the prospects for economic development.

At the same time, this horizontal expansion must be accompanied by reinvestments in the resources and industries that define an area's natural identity and economic base. Such investments are most effective when linkages in the production process from keystone resources to final products are established and maintained locally, a process referred to as *vertical integration* of the local economy. A fully integrated local economy must be integrated in both dimensions—vertical and horizontal. Let us briefly consider each in turn.

Vertical integration. As the analogy suggests, vertical integration proceeds upward as opposed to outward. Using forests as a surrogate for an area's keystone resources, vertical integration begins with direct investments in forests themselves through their management and stewardship. It continues through the primary processing phase of production, which for wood products involves the conversion of logs into products such as lumber, veneer, plywood, pulp, and bulk paper. But rather than exporting most products yielded at this stage to markets within broader regional, national, or international economies, enhancing the quality of life in a rural locality may be better achieved by locally extending production through the stage of secondary processing in which much of the value is added to primary products, e.g., when lumber is converted to wood flooring, furniture, and so on. In the process, income-generating value is added to the product, jobs are created, wages are spent locally, and the economic base for improving the quality of life is solidified.

In such a scenario, local communities will have, in addition to extractive industries, other

firms and businesses that extend the production process at the local level to the point where the maximum income may be derived from the final product. In the process, the direct link between keystone resources and final products is maintained locally, and investments in such resources become an obvious necessity for such a relationship to exist. Moreover, as Norton (1999: 146) observes:

> [V]ertical integration maximizes jobs supported in the geographic location of resource extraction over longer periods of time. These intertemporal values would be manifest in a place-based economy and in decisions that are place-conscious and organized around key resources of the region.... These are the resources that form the basis of place-based regional development. Their loss erodes the distinctiveness of the landscape and the diversity of available habitats in the region.

In rural forested areas such as the Missouri Ozarks, the wood products and recreation and tourism industries are those most directly linked to the consumption of the forest resource. (The minerals industry is another, but that is not our focus here.) The wood products industry comprises three subsectors: timber management and harvesting (including landowners, loggers, and consultants), primary processing, and secondary processing. The fact that more than four-fifths of all forest lands in Missouri are owned by private individuals or groups other than forest industry presents a distinctive challenge on the supply side of the economic equation. For the task at hand is not simply one of ensuring that a few large industrial producers undertake reinvestments in their forest lands consistent with long-term forest sustainability (which would be a good business practice anyway). Rather, the reinvestment task essentially involves attempting to ensure that a large number of small landowners with a wide variety of motivations for land ownership and diverse attitudes toward managing their lands undertake such reinvestments (see Kurtz, this volume).

This suggests that landowners and loggers, by virtue of their number and direct links to the forest, must be a special focus of reinvestments in forests as a keystone resource. Such reinvestments must begin with: (a) providing landowners with information and education regarding options for enhancing the integrity of their forests through sound management practices; and (b) ensuring that loggers harvest timber in an ecologically sound manner. The impetus for accomplishing this task cannot emanate exclusively from the economy itself, although efforts of certain economic actors—e.g., trade associations and wood processing facilities—can play an important role in influencing landowner decisions relative to harvesting. This is one of many examples in which the critical reinvestments in keystone resources required for effective vertical integration of the local economy will require inputs from government, community-based groups, and the like—i.e., those with roles in other dimensions of the local area's social system (fig. 7.5a).

The Missouri Department of Conservation is the principal public forestry agency that provides advice to landowners in the Ozarks and throughout the State through field foresters and natural resource professionals employed in its Forestry and Private Land Services divisions. They may help landowners recognize the multifaceted values inherent in their forests and the range of options that both are consistent with owner objectives and incorporate ecologically sound management practices, thereby promoting the viability of the region's keystone resources. The potential effectiveness of public programs in strengthening on-the-ground forest management is a direct function of adequate funding which, with the exception of assistance offered by groups within the industry, is a matter decided by the polity. These and related concerns were reflected in the recent report of the Governor's Advisory Committee on Chip Mills in Missouri (see Lewis, this volume).

Recreationists and tourists are a major asset in the economy of any rural town or locality: they spend money locally and do not require the most expensive public services.[20] As with

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[20]Wolf (1999: 198) observes that, from a national perspective, wildlife-related tourism now attracts more than 100 million people a year and generates more than $60 billion in revenue. One subsector, birdwatching, brings half a million to several million dollars to every community with a nearby national wildlife refuge. Fishing alone, the favorite recreational activity of American men, brings in over $25 billion annually.

the wood products industry, a focus on recreation and tourism as part of a sustainable economy will depend on efforts of both private businesses and public and community-based agencies and organizations. Opportunities for recreation and tourism depend on public investments in maintaining the integrity and aesthetic character of forests and other keystone resources. Also required are investments in modes of access—i.e., roads, docks, and so forth—and, for tourists not inclined towards roughing it in the wild, comfortable accommodations and sources of indoor entertainment during the evening. Here the private sector has a critical role to play in providing such services. In addition to outdoor activities involving the experience of natural landscapes and settings, whose kind and frequency fluctuate with the cycle of the seasons, tourism driven by interest in the past has the potential to stimulate local economic growth on a year-round basis. Historic sites or districts attract not only visitors but also residents who take pride in quality restoration and community preservation.

Strategies for enhancing an area's economy through recreation and tourism will, of course, depend on the size and economic status of particular localities in the region, along with associated assets available for investment. In the Missouri Ozarks, for example, the Branson area finds itself at a more advanced stage of developing a recreation and tourist-based economy. The travel-destination counties in southwest Missouri (fig. 7.4) are, however, beginning to confront the new realities that accompany economic growth. Echoing concerns regarding the protection of an area's keystone resources, Wolf (1999: 197-199) summarizes the implications of the economic boom in tourist "hot towns" for long-term economic sustainability as follows:

> For tourism to be a long-term boost to the local economy, specific policies must be set. Regulating tourist-oriented commercial development with a sound land-use plan is crucial. Building height limitations, scenic vista protection, sign control and thoughtful illumination standards all help protect the community's appearance. The types and pace of development of overnight accommodations must be calibrated. The sites—building, river course, trail, battlefield—must be sensibly protected if a community wishes to maintain its appeal to visitors and residents, its economic diversity, and its cherished specialness.... A smart growth town will not allow tourism to drive out significant local enterprise or compromise local resources such as a beautiful landscape.

For small towns such as many in the eastern Ozarks, the focus will likely have to be limited to the provision of a few of the basic elements highlighted above. Wolf (1999: 203) describes how a small community in Colorado reacted to a scenario much more likely to reflect the situation in the eastern Ozarks. He notes that historically mill towns, mining towns, company towns and the like have invariably been at risk. In many such communities, an extractive industry serves as the primary employer, and should it terminate operations, an extended and harrowing period ensues in which the community attempts to diversify its economy. Sometimes, as in the case of Kremmling, Colorado, where Louisiana-Pacific closed its waferboard mill, the experience may yield positive results in the long run:

> The consequences seemed so dire that residents could not at first envision a future. Town manager Bill Koelm observed that the shutdown was "kind of equivalent to the Martians landing in town square." The shock eventually led to new long-term plans. Residents formed an economic-development committee that conceived a plan intended to nurture an environmentally sound, diverse economy. The result was Kremmling's "Vision for the Future," an ambitious set of twenty-one projects ranging from a new motel to a ranching museum to scenic bikeways.

In the case of Kremmling, it took the concerted efforts of local residents facing a dire situation for all involved to cooperatively forge a pathway to sustaining its economy and quality of life. For many communities in the eastern Ozarks and elsewhere, which have long been in economic distress, forging a sustainable economy will require significant inputs and assistance from broader public sources—i.e., county, State or Federal funds, regional advisory councils, and so forth—to initiate and sustain such a course for economic development. Moreover, grounding such development

in a vertically integrated local economy that protects and nurtures an area's keystone resources is essential to establishing and sustaining the "horizontal" linkages that constitute the second critical dimension of a genuinely sustainable local economy.

Horizontal integration. Let us return briefly to the extractive model of the economy (fig. 7.7a), which reflects the economic base perspective for a resource-dependent economy. In this model, exports and the income they inject into the local economy are the major driving forces of all other economic activities. The income earned from exporting activities circulates through the local economy, and a multiplier effect creates locally oriented jobs in services and other sectors that account for the majority of local employment. Vertical integration is essentially concerned with extending the local production process through a value-added stage *before* final products are exported. However, exports and the horizontal linkages with broader economies they entail are still an essential aspect of a fully integrated economy. Unfortunately, the orthodox extractive model of resource-dependent economies, in addition to downplaying the investments necessary for vertical integration, also does not capture the full scope and dynamics of these horizontal linkages.

A major difficulty with the traditional perspective is that there are other potentially stabilizing forces present within these resource-dependent communities that are overlooked by the model and yet may have a significant effect on the nature and trajectory of the economic multiplier. For as Power (1995: 243) observes:

> First and foremost, the multiplier is determined by the character and structure of the local economy. The more quickly the injected income "leaks" out of the local economy, the smaller the multiplier effect.... The more self-sufficient a local economy is—and thus the smaller the fraction of local spending that goes towards imports—the longer the income from exports that is injected into the local economy circulates within it and the larger is the overall multiplier effect.

This suggests that it is more than simply the level of export income that dictates local economic impacts, but also the structure of the local economy itself as reflected in the range of locally produced goods and services available. The more of the latter that exist, the less the need to import them, and the smaller the leakages of export earnings back out into the external economy. Thus, far from being less important, secondary, or derivative sectors, service and other non-exporting businesses perform the critical function of absorbing and holding dollars longer *within* the local economy, with positive effects on employment and income:

> [I]t is the richness and diversity of those locally oriented sectors that make a crucial contribution to the size of the multiplier.... Economic development consists of elaboration of a more complex web of locally oriented economic activities that make an area increasingly *less* dependent on imports, and as a result, not as dependent on export earnings.

A direct implication is that a strategy for economic sustainability that focuses exclusively on expanding an already specialized export industry—i.e., a "more of the same" approach—is rarely by itself sufficient for sustainable economic development. In fact, increased specialization in a few exports can often have the opposite effect, serving as a prescription for dependence and instability.

Also missing within the extractive model are any hints as to sources of income for the local community that are substantial yet not tied directly to exports. Much of this latter income base is directly or indirectly related to an area's attractive qualities as a place to live. In addition to the fact that individuals and families relocating to a preferred area are likely to bring savings with them, such characteristics may also be appealing to small businesses that are fairly flexible and can follow the locational preferences of their owners.[21] In

[21]Another important source of income is that generated by expenditures of recreationists and tourists who visit a particular location because of special features of its natural or cultural environment. This was considered in the previous discussion of vertical integration of the local economy. It should be noted that the standard economic base model (although not in the extractive version) does recognize tourism as an exporting industry—albeit an unusual one in that the exported product is consumed on site in the local area.

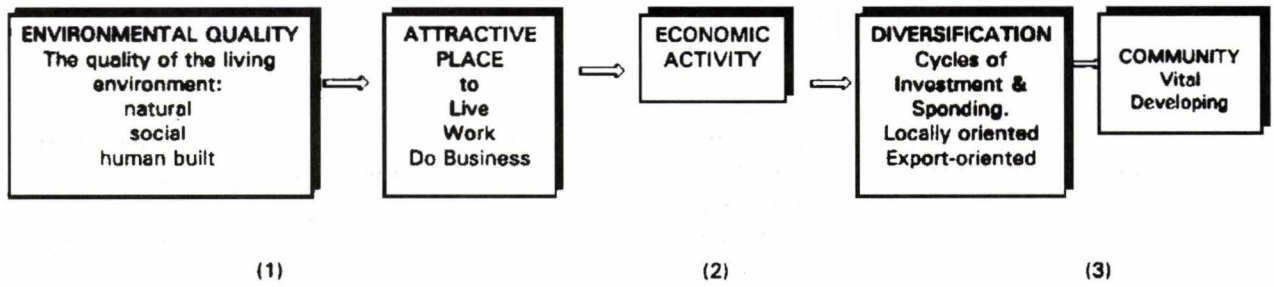

Figure 7.7b—*The quality-of-life model of the local economy. (Source: Power 1995: 248).*

addition, other income from sources external to the local economy—e.g., retirement income, investment earnings, government income support payments—is spent locally. Whatever features of the local area attract or hold all of these kinds of income are a major part of the local economic base, even though most involve no exports. In some areas these non-labor income flows may in the aggregate exceed the total income generated by extractive industries. It was noted earlier, for example, that for most of the Missouri Ozarks, the health care system, supported to a large degree through transfer payments from the Federal government, exerts the largest impact on the economic multiplier for the region. Finally, effective import substitution—i.e., producing products locally that an area would otherwise have to import—often results in a diversification of the local economy that ultimately may enhance its ability to produce new exports.

In this light, a revised version of the economic base model is warranted, one in which not only exports but also local economic activity matters as well. Power (1995: 246-249) outlines such a pathway to economic sustainability, one which posits quality of life—the key focus of social sustainability noted earlier—as a much more prominent driving force in the process (fig. 7.7b). The logic underlying the "ideal" formulation of this pathway begins with the notion that people have preferences for living environments and act to satisfy them by moving to areas that can offer their desired social and natural environments. This creates an available supply of affordable labor in these areas, which in turn attracts economic activity. In addition, the decisions by people to settle in the area are likely to inject income into the local economy as individuals expand savings and make investments in seeking to make a living. Retirement incomes may also follow the locational decisions of retirees. The net effect on the local economy is expansionary, and as the economy grows, entrepreneurs will explore opportunities to replace imported goods and capture money that would otherwise flow out of the area by developing a desired variety of locally available goods and services. Finally, those businesses that are most successful at displacing imports and serving local needs will build on that success and begin exporting products to the broader regional, national, and international economies.

All of the above increases the number of residents that the local economy can support, bolstering its critical mass by expanding the range of goods and services that can be produced and marketed locally. At the same time, barriers posed by isolation and costs of imports that would previously have inhibited new firms from relocating in the area are reduced. Such a pathway to sustainability will remain viable as long as the area continues to be a relatively attractive place to live, work, and do business.

When a community depends on a single or small number of employers, it is inherently at the mercy of market forces tied to one or two industries. The obvious implication is for any town or area to promote *job diversity*. Part of this involves crafting incentives based on a realistic assessment of those firms that would most likely find the area attractive and, therefore, be willing to locate there. Diversifying a town's economic base is a key means of enhancing horizontal integration within broader external economies. It involves asking all the questions inherent in the general one posed earlier in this discussion—i.e., what

makes a business want to locate in the area? Any firm genuinely interested in success arising from the productive contributions of employees who like what they do and are satisfied where they live will have a number of basic concerns when deciding where to (re)locate. Among these are the natural setting of the community, the cost of living in the local area, the quality of available housing, public (and in today's information economy, communications) infrastructure, the willingness of local business and financial institutions to provide assistance when feasible, and community policies regarding such matters as land use, tax incentives, health, and education.

A critical aspect of effective horizontal integration of local rural economies is achieved by creating and *strengthening linkages between rural and urban markets.* That is to say, even if value-added products are produced via a vertically integrated local economy, it is still critical that connections be established to markets where steady consumption patterns can be assured. There is no single prescription for accomplishing this task, and much will depend on the initiative and entrepreneurial skills of those guiding individual firms. At the same time, advice and assistance may be available from regional, State, and Federal economic development agencies, often in the form of initiatives and programs accessible through regional or local intermediaries.

A fully integrated local economy. From the foregoing discussion it is evident that both vertical and horizontal integration are important to a fully integrated local economy. The former is critical for the protection of an area's forests and other keystone resources. Horizontal integration strengthens the local economy by forging and maintaining ties with broader regional, national, and international economies. It is possible, however, that local communities can mistakenly emphasize the horizontal dimension at the expense of, rather than in conjunction with, the vertical dimension, with negative effects on forest and other resource sustainability. Norton (1999: 144-145) describes such a scenario, noting that it is actually consistent with the traditional profit-maximizing economic strategies that accompany the goal of maximizing economic growth. Here, profits are initially generated from the development and use of an area's keystone resources. But these profits are reinvested not in those resources or industries dependent on them, but in industries offering a higher return on investment than the former. After all, as noted earlier, economic growth is maximized by continually reinvesting profits in ventures yielding the highest return; and such profits are place-independent, in the sense that there is no guarantee that locally derived profits will be reinvested in the local area or region. In short, "the investment side of the model has no place orientation; there is no built-in preference for local investment."

As investments shift from the natural resource base of the region to these other higher return sectors in the broader economy, local natural resources become less important and the nature of the local economy changes as well. For when local investors forego investing in the resource base, local communities are forced to rely exclusively on their ability to become players in this broader economy as well. The object of community investments shifts away from the resource and towards other factors that will presumably help lure non-resource oriented businesses to locate in the area. As Norton (1999: 147-148) continues:

> To compete for investors, the region must out-compete other regions for "place-independent" industries, which will locate where costs of labor or taxes are lowest. Communities compete by impoverishing themselves, and often by sacrificing the distinctive features of the life-style their ancestors have developed in their local place in order to attract this place-independent development.... We would expect such a process to lock into a self-reinforcing gradual decline in the motivation to protect local resources.

In light of their history and present economic status, many localities in the Ozarks find themselves facing continuing pressure to "plug into" the later stages of the above pathway. That is, it is becoming more difficult to resist pressures to shift the focus of investment from forest sustainability to efforts to lure place-independent industries from other parts of the broader, more integrated national and global economies to locate in the local area. As this is more or less successfully achieved, however, "competition drifts further and further from any anchoring identity based on the natural history of the region." The key lesson here is that horizontal linkages can be forged without

place-oriented investments, but that sustaining the vertical linkages grounded in investments in the forests and other keystone resources is also essential both for sustaining those resources and for forging a fully integrated local economy in the long run.

Incentives, opportunities, and responsibilities. It is well recognized that the largest contribution to economic growth in this country emanates from small and medium-sized enterprises. Attracting these firms to become participants in local rural economies is thus an important step in the quest for economic sustainability. This is true whether a firm's primary role is in contributing to either vertical or horizontal integration of the local economy. Any such firm is likely to take notice of *business and entrepreneurial incentives* supporting place-based economic development. In the horizontal dimension, for example, startup incentives for *microbusinesses*—i.e., those with four or fewer employees—would focus on the increasing numbers of individuals who are migrating to rural areas to pursue their business or professional careers while enjoying the quality of life provided by a rural setting. Many such businesses would require that a suitable communications infrastructure (e.g., Internet hookups) be available. This is equally true for the increasing number of Americans (now more than 30 million) who work at home at least part of the time. For small to midsize towns in particular, accommodating people at home, where they may combine childcare with the workplace, is an effective way to retain productivity in the community. People who do not have to commute to another town to work are, in turn, more likely to spend money locally, be better integrated in local life, and care more about their town's future. In essence, these are people to whom ties to place are unnecessary for their professional interests but vital as the setting for their daily lives. Focusing on vertical integration of local economies, another potential for targeted incentives is for businesses engaged in *niche manufacturing* or the provision of products with specialized markets, often for products derived from resources distinctive to the locality or region in which they are produced (see Jones, this volume). Many of the firms and businesses that make up both the primary and secondary wood products industry, as well as those that provide services for recreationists and tourists, can benefit from the creation of incentives for small and medium enterprises.

A focus on entrepreneurship entails special attention to small business startups and technological innovation. Not only is entrepreneurship a direct source of jobs, but its new ideas foster competition, promote technological development and, in today's swiftly changing economy, provide individuals with a basis for self-employment during times of transition. Government policies can provide direct support for entrepreneurship via programs that supply venture capital. More generally, many community initiatives are spearheaded by groups that lack the experience, fiscal resources, and time to work with complex administrative structures of government. There is a need, as emphasized by the President's Council on Sustainability (Sitarz, ed. 1998: 86-88), to develop innovative financing programs to improve *access to capital* for small businesses and communities so that they may more easily invest in technologies and practices that improve resource efficiency, reduce waste, and add value to local economies. This will require support from public sources beyond the level of local government for capital infusion into projects and programs that are likely to make a difference at the local level. One long-standing example would involve Federal and State support for community-owned banks. Local ownership of investment capital is more likely to result in a higher level of place-based community investment. Tapping such alternative capital markets would, hopefully, eventually result in broader market responses.

Finally, it has been emphasized that protecting forests and other keystone resources must be a cornerstone of all public and private efforts toward growing a sustainable economy. This will clearly require the genuine *commitment of businesses* in both natural resource-based and other economic sectors. As Selman (1996: 128) observes, businesses can provide leadership and support for sustaining an area's keystone resources by sponsorship of local initiatives for sustainability, as well as utilizing the workplace as a form of adult education, in the informal sense, by enhancing employee awareness of environmentally responsible production practices. All types of businesses can adopt practices such as recycling and environmentally sound handling of toxic materials. Businesses can also be a major contributor to

enhancing participatory democracy through their relationship to community efforts and public- private partnerships discussed below. Among the most significant ways in which firms and business organizations can enhance the sustainability of keystone resources in a locality or region is by developing environmentally sensitive management, accounting, and auditing systems. Within the forest products industry, one example of an effort in this direction is the Sustainable Forestry Initiative (SFI) of the American Forest and Paper Association (AF&PA), which has been endorsed by the Missouri Forest Products Association. SFI has identified a series of best management practices to be implemented on all forest lands owned by association members to ensure long-term forest sustainability.[22]

Businesses can also promote sustainable land management practices in the broader economic community through the "chaining of responsibility" via requirements that subcontractors and suppliers have to satisfy certain environmental criteria in producing their products if they are to perform services for or provide goods or supplies to the focal business. Many major companies are becoming increasingly demanding in this respect, which undoubtedly bolsters their corporate image as well. A case in point is the recent declaration of Home Depot, Inc., that it will only accept wood products that have been certified by the Forest Stewardship Council (FSC) as having been produced through the use of ecologically sound forest management practices. FSC is an international non-profit organization that certifies forest products as coming from forests that meet a set of principles and criteria for sustainable forest management.[23] Both public and private lands may be evaluated for FSC product certification. In the past few years forest certification has received increasing attention as a potentially effective way for providing an "ecological insurance policy" to the process that begins with timber harvesting and culminates in the final product—i.e., the core production chain for wood products. In the Missouri Ozarks, certification of this entire "chain of custody" is being promoted by a not-for-profit organization known as Value Missouri, comprised of several members of the wood products industry (i.e., sawmill owners and secondary processors), representatives of environmental groups, loggers, and private landowners, including the State's largest private holding, the 155,000-acre Pioneer Forest.

In summary, as an integral part of local communities, businesses must be solicited as major players in the quest for a sustainable economy. Firms can foster *accountability* by adopting integrated or holistic concepts through a blend of targets, quality assurance systems, audits, and in-house training. Effective audits for self-monitoring in turn enhance trust through *transparency*, since they result from techniques that can give rigor and testability to claims of environmental performance. In the process, criticisms of a superficial "green veneer" may fade with the adoption of sustainability as a basic principle of business strategy, one reflecting its role as a key player in sustaining the quality of life in rural localities.

At the same time, *quality of life* is a principal goal and primary manifestation of *social* sustainability, which includes but goes beyond promoting a sustainable economy. In this light, the pathway to *economic* sustainability depicted in figure 7.6 presumes its own embeddedness within a broader multidimensional pathway to *social* sustainability in the region or community. In short, achieving economic sustainability is part of a broader process or pathway to social sustainability.

THE FABRIC OF SOCIAL SUSTAINABILITY

Much of the preceding discussion has suggested that, in addition to measures adopted by firms and other economic actors, substantial impetus for a sustainable economy must come from government and the political sector; will be enhanced by the underlying force of community solidarity, and will be supported by shared ways of understanding and living in the world that are the essence of a local culture. Similarly, a healthy economy itself may

[22]AF&PA is also encouraging its members to have their adherence to these BMP targets validated via a third-party verification system that includes forestry professionals from outside the industry as a key component of the monitoring team.

[23]The forest inspections are carried out by a number of FSC accredited certification bodies, which are evaluated and monitored to ensure their competence and credibility. FSC accredited certification bodies are required to evaluate all forests aiming for certification according to a set of FSC principles and criteria for forest stewardship.

contribute to strengthening these other dimensions of social life and to attaining the quality of life that is the essence of social sustainability. Thus, it is important to examine these other dimensions of life in rural localities in terms of both their critical contributions to social sustainability and, in the process, their potential for enhancing the prospects for a sustainable economy. While it is not possible here to consider all of the elements listed in figure 7.6, several of the most important are discussed below. These include the critical importance of opportunities and processes for collective decisionmaking in governance; the crucial role of civic engagement and public-private partnerships in mobilizing social solidarity; and the linking of cultural landscapes and keystone resources to the processes through which an intergenerational vision of place-based cultural identity for people of the Missouri Ozarks may be sustained.

GOVERNING SUSTAINABILITY

The political dimension of social life in rural forested areas encompasses the realm of collective decisionmaking through which the quality of local life is maintained. Government plays a key role in this process, as elected officials, agency personnel, members of the judiciary, and others make decisions and implement programs in the public interest. Stewart and Hams (1991) identified a variety of reasons why effective local government is fundamental to achieving social sustainability. Local authorities are invariably close to many of the issues, e.g., land use changes, local health and safety concerns, and so forth. They have a significant potential for capacity building in the sense of providing people with the knowledge, abilities, and resources to build a sustainable community. They "grease the machinery" of local democracy, conducting meetings and hearings that provide a venue for citizen participation. Members of local government are also well positioned to be sensitive to local identities and needs, and can therefore accommodate local differences, diversity, and innovation. They can motivate local residents to act for collective purposes and may themselves be a starting point for new initiatives. They can also create or tap into initiatives that extend beyond the local community across counties, regions, and ultimately, the State of Missouri and the Federal government.

As the political authority closest to the citizen, local governments perform several key functions. Through policies related to land use, they have the ability to safeguard an area's keystone resources. They can also create and support economic development efforts, and they provide or mediate the delivery of numerous social services upon which rural residents depend, including public infrastructure, security, health, and the provision of a viable safety net for community residents. Many of these services rely on State and Federal funding and grants to supplement revenues derived from local sales and property taxes, both of which play important roles in supporting school districts and providing a number of community services.

Ozark residents are members of political jurisdictions at different levels—from school district to county to State and Nation. An effective polity requires numerous *loci of collective decisionmaking* to accompany this jurisdictional hierarchy. Larger municipalities invariably have a town council or board of commissioners, along with a variety of more specialized commissions (e.g., planning and zoning, housing). Smaller towns may only have a town council; and most very small towns, along with citizens who live in the open countryside, have to rely principally upon county governments for essential services and other governmental functions. In 20 of the 26 non-metropolitan national forest (NMNF) counties on which this article focuses, more than three-fifths of county residents live outside of incorporated places, while for the remaining six counties, each with a medium-size town situated within its boundaries, between two- and three-fifths of county residents live outside the boundaries of such places (OSEDA 2001).[24]

The challenge of governing sustainability often becomes apparent to local governments when, in dealing with the range of funding sources, programs and initiatives emanating from higher levels of government, they find themselves without an overall framework or set of policies that can tie all of these programs together at the local level. One means of framing a collective vision for the future is via a *formal planning*

[24]Counties (and respective communities) in this latter group include Butler (Poplar Bluff), Howell (West Plains), Laclede (Lebanon), Madison (Fredricktown), Phelps (Rolla), and St. Francois (Farmington).

process for a community or local area. Ideally, land use planning and related measures such as zoning and building codes are the major instruments available for a community to develop a strategy for placed-based development. Such plans deal not only with the general pattern of land use, including controls over specific uses, but also with the character and location of public buildings, streets, transportation systems, and facilities that promote economic development and general welfare. The State of Missouri has a set of regulations for implementing land use planning by municipal and county governments, and some municipal planning activities are undertaken in a few communities in the Missouri Ozarks. However, county-level planning in the Ozarks is extremely limited, and it seldom includes any form of zoning or land use control.[25] The current situation and prospects for improvement were addressed in the Ozark-Ouachita Highlands Assessment (USDA Forest Service 1999: 86-88):

> [T]he political acceptability of planning and related activities such as zoning and growth management has always been very low in the Ozark-Ouachita Highlands. Although Missouri does allow counties to plan and zone, very few do either. Those that have initiated planning activities usually avoid zoning, the major instrument available for implementing plans.... Community development specialists believe their residents will favor development strategies that extend to include other communities or even multi-county areas or regions only if they can: (1) see the benefits of economies of scale due to working together rather than individually; and (2) be assured that the planning effort is not an attempt to replace county/city autonomy. In addition, local officials must feel that such efforts enhance their ability to better serve those who elected them.

Few, if any, of the smallest Ozark communities are able to conduct any kind of planning activities. For such towns and outlying rural populations, there are two kinds of broader regional organizations that may include planning functions. In Missouri, a number of multi-jurisdictional strategic planning organizations exist in the form of regional planning commissions. These are quasi-governmental agencies governed by boards of directors comprised of public officials representing the counties and municipalities they serve, as well as representatives of the private sector. Their basic purposes are to facilitate cooperation among local governments in addressing problems and opportunities common to their region and, where possible, to conduct long-range planning and development efforts, and provide technical assistance (e.g., aid in preparing grant applications) to member counties. Counties may in turn aid in creating or implementing transportation plans, recreation plans, and water and sewer projects for individual communities within their jurisdiction. In some places where county and municipal planning is rare, such as the Ozark Foothills District encompassing five counties in the eastern Ozarks, the regional planning commission serves as *the* primary planning organization in the area.[26]

Another group of regional organizations concerned with land use in the Ozarks are

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[25]In a few instances, specialized planning efforts are undertaken in connection with programs supported by particular government agencies. The Ozark-Ouachita Highlands Communities Project (USDA Forest Service and University of Arkansas Cooperative Extension Service) has provided funds to several counties and communities in the Missouri Ozarks for strategic planning efforts related to community development. Stone and Iron Counties have participated in the program, the latter receiving about $80,000 from 1994 to 1997 to develop a county-wide community development strategy that relies heavily on tourism. The community of Salem in Dent County has also participated in the program.

[26]The relationship of the 26 non-metropolitan national forest (NMNF) counties to the regional planning commissions in the State is as follows: The Ozark Foothills Regional Planning Commission is made up of five NMNF counties in the eastern Ozarks. The South Central Ozarks Council of Governments is comprised of seven NMNF counties. The Southeast Missouri Regional Planning & Economic Development Commission is comprised of five NMNF counties on the northeastern edge of the Ozarks. The other eight NMNF counties belong (with others) to either the Meramec Regional Planning Commission, the Lake of the Ozarks Council of Governments, or the Southwest Missouri Advisory Council of Governments. (Source: USDA Forest Service 1999: 88).

resource conservation and development (RC&D) councils, overseen by the USDA Natural Resources Conservation Service (NRCS). These councils, which generally function across multi-county areas, focus on promoting sustainable resource management practices in conjunction with enhancing economic development on a regional basis across the State.[27] A council is generally formed by establishing partnerships with other Federal, State, and private entities for developing local land and water resources for farming and industrial use, expanding recreation and employment opportunities, and promoting rural development. The councils may attempt to provide the initial steps needed for a local land use planning process and then allow localities to monitor plan implementation. Some typical activities undertaken by RC&D councils in the Ozarks include planning for forest products and poultry waste management, promoting alternative crop and pasture management regimes, monitoring water quality, and establishing rural fire protection for vulnerable areas (USDA NRCS 1997).

Although multi-county organizations encompass many small towns and residents in outlying areas within their range of activities, their role is generally advisory and they have no authority to make binding decisions. As Mazmanian and Kraft (1999) have emphasized, regional councils have proven to be effective in urban areas as part of a realistic approach to metropolitan governance (a noteworthy example is the Metropolitan Council in Minnesota whose members include the suburban counties surrounding Minneapolis-St Paul). Their need and potential value are at least as great in rural forested areas such as the Missouri Ozarks that lack the capital and other resources characteristic of larger urban settings. Indeed, the beginnings of an effective strategy toward economic and social sustainability could involve bolstering the status and responsibilities of existing groups with similar functions in the Ozarks. Such an effort would need to draw upon the valuable reservoir of local residents with knowledge and experience in both the public and private sectors. A plan is a vision; a regional or community plan is a collective vision; and it is precisely this collective vision that is both an invaluable asset to charting a course for social and economic sustainability and all too frequently in shortest supply in many rural forested areas.

Using a regional model as an example, how might such an organization go about addressing its task in an effective way? First, it would emphasize at the outset that its recommendations reflect the vision of Ozark residents, some of whom may be members of the board itself, whose opinions have been solicited through extensive public participation accompanying the entire process. It would also emphasize that, as they have historically, individual rights regarding person and property are paramount concerns even as a collective vision that extends beyond individual interests is being formulated and implemented. Secondly, the board must have some authority to put its recommendations into practice or, if the past is any guide, their efforts and recommendations will be ignored should they be perceived to impinge at all on individual actions. This is particularly important with respect to actions of investors or speculators in keystone resources who have no ties to the local area or community and little interest in whether any collective vision for the future formed by area residents even exists, much less what it might contain. The importance of producing a *document* that contains the vision of local residents cannot be overemphasized; for all too often well-intentioned regional commissions, attempting to fill a void, end up narrowing their focus to carrying out specific projects easier to complete and evaluate and losing sight of the overall vision. A planning board would also have to have monitoring capabilities in place, something that would inevitably require cooperation with state or other agencies equipped with resources to conduct such activities. In short, there is a vital need to rationalize the planning process for different segments of the population—e.g., municipalities, towns, Ozark residents living in unincorporated places—while maintaining a regional perspective as well. This would ensure that the interests of localities—from unincorporated places to larger towns and municipalities—are integrated within an overall vision for the region, and that the region's forests, lakes, rivers, and other keystone resources are also integrated not only as local assets but also as broader entities such as watersheds and ecosystems.

[27]With respect to NMNF counties, four Missouri RC&D Councils are relevant. The Big Springs Council includes five counties in the eastern Ozarks. The Top of the Ozarks Council encompasses 10 NMNF counties in the central Ozarks. The other 11 NMNF counties are split among several RC&D Councils.

As suggested in the Ozark-Ouachita Assessment, resistance to planning, and in particular zoning, is in part a cultural phenomenon, reflecting the past history of distaste for government making decisions that may impact individual freedoms. While there is indeed a historical basis for such feelings (see Flader, this volume), as areas in the Ozarks such as Branson are discovering, even success in economic development efforts, much less reversing the continuing stagnation in other rural areas, must involve shaping a vision that both protects the region's natural and cultural identity and reflects a collective consensus forged through a process in which all interested residents have the opportunity to participate and to influence. In short, simply letting nature take its course in human affairs is not a prescription that offers any hope to the Ozarks, and acknowledging this at the outset may indeed be one of the most important steps on a pathway to sustainability.

Planning for economic development is, of course, only one important ingredient in efforts towards promoting a sustainable economy. Local governments and related organizations must also be willing to invest public resources in guiding the path of growth in the region and to devote public funds to shaping investment patterns to favor economic diversification based on existing resources. As discussed earlier, the kind of development to be pursued here is that which maximizes the amount of locally recoverable value added per unit of resource extracted. Placed-based business and tax incentives skillfully formulated and combined might effectively link revenues derived from responsibly harvested keystone resources such as timber with incentives for locally owned businesses. Thus, for example, as Norton (1999: 145) advocates, receipts from a small tax on resource extraction might be channeled into startup loans for cooperatives and other locally based businesses that process timber or use locally grown and milled lumber to make furniture or components of houses for construction, and so forth. Local government can also play an important role in helping businesses take advantage of other incentives available as part of State and Federal programs. Regarding the latter, some of these initiatives have been tailored specifically to address the needs of counties in which a significant portion of the population is at income levels at or below the poverty line (U.S. Department of Housing and Urban Development 2001a, 2001b). Local governments can play similar roles in acquiring State and Federal funds for public infrastructure projects and social services programs.

SUSTAINING SOCIAL SOLIDARITY

From all of the above, it is evident that if strategies for enhancing social and economic sustainability in the Missouri Ozarks are to succeed, they must somehow combine the effectiveness of local governments with the vigor of citizen action. For citizens to reflect a common vision of a community's future will require willingness to cooperate in creating the kind of social solidarity that looks beyond self-interest to the shared destiny of people living in a particular place. A key requisite for this is a viable *public sphere*, i.e., forums for public discussion accessible to all citizens who desire to participate. Such outlets must include not only collective gatherings of private groups and associations, but also the kind of forums provided by public and governmental bodies as part of the process of local governance. All such forums reflect the fact that social sustainability is more likely to evolve out of deliberating with others about future directions for the community or region, and this in turn requires a variety of *opportunities* for such deliberations. In addition, by allowing local citizens to participate in opinion-gathering or highly consultative forums in close proximity to local issues, vested interests are more manageable and expressions of personal conscience are recognized and respected.

A strong degree of *civic engagement* in which individual citizens are motivated to express their desires and concerns about community issues must be a central component of any pathway to social sustainability. With respect to participation in the polity, the emphasis on local decisionmaking is a cherished tradition in American community development. But in the past there has been a tendency for many public boards or commissions to be dominated by those with politically or financially powerful interests. With respect to quasi-governmental and non-government public advisory bodies, a different scenario frequently occurs. Here the advisory board may be comprised of a number of local agency professionals genuinely interested in the problems at hand, but with an inadequate representation of ordinary citizens (e.g., farmers, forest landowners) who ideally

would be selected on the basis of their knowledge of the subject and ability to represent the diversity within their particular groups. Such individuals have valuable contributions to make to collective decisionmaking and advisory bodies, and a wise community will seek out their participation.

In a practical vein, several factors may enhance both the effectiveness of citizen participation and the potential for success in consensus-building for decisionmaking or advisory groups (Selman 1996: 79). All stakeholders should be given strong reasons for participating; they should be accountable to their constituencies and be involved from the start and treated equally. Both rational and emotional interests of participants need to be acknowledged and respected, and the focus should be on people's concerns rather than their personalities. The time frame must be sufficient for people to get to know and trust each other, and they should work with a common information base. There needs to be flexibility in framing and implementing solutions and commitment to abide by outcomes. As a general rule, and unlike elected governmental decisionmaking bodies, decisions should be made by consensus. The process should result in a written plan that embodies a common vision, along with options for realizing that vision and overcoming obstacles to it. And finally, the process should not simply terminate with agreement on a solution, but continue with a commitment to implementation and monitoring. Independent third parties (mediators/facilitators) are another option for working with stakeholders and helping structure the overall process. Ideally, such a process would be characterized by honesty, trust, inclusiveness, and mutual education.

When it comes to ensuring citizen participation, the composition of local or regional decisionmaking boards can and often should take the form of *partnerships* between public and private groups dedicated to forging a viable pathway to social sustainability. This reflects the common-sense recognition that in order to arrive at a shared vision of a community or region's future, the entire range of community priorities—from protecting keystone resources to shaping a sustainable economy, preserving historic character, and so on—can only be realized if participants from both public and private sectors adjust and integrate their respective goals and priorities derived in part from their particular roles in the community.

Partnerships may be effective in addressing the entire spectrum of factors relevant to attaining economic and social sustainability. Thus in mid- to large-size towns they may be geared towards enhancing economic development and take the form of business improvement districts. In smaller rural communities, partnerships may address the task of creating a plan for protecting an area's keystone resources such as watersheds or ecosystems. A noteworthy example of such an approach is the Missouri Watershed Initiative begun in 1997 for the town of Macon in north central Missouri, in which a citizen group has interacted with university scientists to study the Long Branch watershed and develop a management plan.[28] In rural forested areas, the focus may center on promoting sustainable forests and forestry practices, as exemplified in southeast Missouri by the Eastern Ozarks Community Forestry Resource Council[29] and by Value Missouri. Formed in part as a response to the recent controversy over chip mills in the State, Value Missouri promotes educational efforts to help landowners recognize the range of alternatives for forest management as well as promoting the concept of forest certification for private forest landowners.

Similar kinds of efforts may be directed at enhancing social life in local communities, as is the case with the town of Salem, Missouri.

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[28]The Long Branch Watershed was selected as a pilot project area in 1998 to test a process for community involvement in watershed management/restoration developed through the Missouri Watershed Initiative. Initial funding was provided through a grant from the Environmental Protection Agency. A local steering committee was formed to develop an action plan for long-term watershed sustainability consistent with community and stakeholder expectations. This was complemented by a technical group comprised of representatives of the several local, State and Federal agencies who work within the watershed and are involved with matters related to water quality. Physical, biological, and socioeconomic characteristics of the Long Branch Watershed were inventoried and described in a series of assessment projects undertaken in 1998 and completed a year later. Project scientists reported their results to the steering committee, and these served as input for development of a watershed management plan.

Concerned about the need for a viable community gathering place, which had been limited to churches prior to this initiative, the community formed a project committee to address the issue. With the aid of a concerned local donor, the committee obtained a 75-acre tract on the outskirts of town, as well as funding from grants and donations, to construct multiple-use facilities that would be home to the county fair for one week each year and then used year-round for other types of recreational and educational activities (Commons Project Committee 2001). The Commons Project Committee—comprised of nine local citizens, only one of whom is an agency official—has raised more than $550,000 from private donations, a USDA Rural Development grant, and smaller grants. The creation of such groups reflects a growing predisposition among Ozark residents to become engaged in co- operative projects that are clearly aimed at enhancing the quality of life in communities and their surroundings.

Private non-profit associations are another important community asset with a special role to play not only as potential participants in partnerships, but by virtue of their distinctive contributions to the community dimension of social life. Organizations such as the Lions Club, Kiwanis, Rotary, garden clubs, and so on, not only strengthen a community's public sphere by providing forums for public discussion, but also establish social networks for residents with common interests and serve as models for youth to learn about their community. In addition to their role in providing a range of health-related and other social services to less fortunate members of the community, non-profit groups are also advocates for improvements in these and other areas; and working together they can make a big difference in the precise policies that public officials may pursue.

In midsize and larger towns, such citizen groups are also well positioned to be effective advocates for preserving public space, reminding local governments of their responsibilities for enhancing physical settings that serve the dual purpose of contributing to a vibrant public sphere and preserving the aesthetic character of the community. Homeowners associations, which are simply groups of private citizens acting to improve the neighborhoods or districts in which they live, are becoming another influential segment of the private sector. When combined with trade associations, environmental advocacy groups, and the whole range of organizations that provide social services geared towards those less well-off in the community, a vibrant local private and non-profit sector can perform a vital function in enhancing social solidarity as a key ingredient of the quality of life in a community.

When evaluating the overall costs and benefits of strategies for enhancing civic engagement in communities and regions of the Missouri Ozarks, a number of points are relevant. On the one hand, efforts to involve citizens should be undertaken with full awareness that achieving community-wide civic engagement is a daunting task. It takes time, patience, and determination just to engage a significant proportion of private residents and community leaders. The broader the scope of participation, the more time required and the greater the potential for slow progress and frustration among the public. Among the most challenging aspects of the task is that of enticing otherwise indifferent constituents to participate. Equally difficult at times is the task of convincing local leaders about appropriate courses of action and energizing them to pursue

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[29]Formed in the late 1990s, the council's goal is to increase the knowledge of communities and private forest land owners in the region about the range of forest products and their value, best management and other practices involved in sustainable forestry, improved timber harvesting techniques, and developing strategies for the marketing of woodland products. The composition of the council reflects a partnership among a Federal agency (USDA) and its subdivisions (USDA Forest Service, Big Springs RC&D Council, and Farm Services Agency); the Missouri Department of Conservation (MDC); Extension and Outreach Divisions of the University of Missouri and Lincoln University; and representatives from forest industry, private forest consultants, and private forest landowners. Among the group's primary strategies for "revitalizing communities through forestry" are coordinating forest activities in the regions conducted by various Federal, State, local, and university groups; promoting the formation of forestry cooperatives; expanding MDC's Master Tree Program for private landowners; and seeking funding for education efforts for landowners and expanding youth education opportunities. Having overcome the difficulties in becoming established and recognized, the group is now beginning to focus on implementing the above strategies and making a substantive contribution to enhancing forest sustainability in the region.

such pathways. Participatory processes also entail a great deal of effort and expense in setting up meetings, managing the overall process, and reporting on outcomes. Effective public involvement may require mass mailings, a public educational program, announcements in citizens' organizations and at public meetings, and other measures. Engaging the local news media, an important participant in an effective public sphere, is also critical. Ultimately, the whole process may still collapse, especially if various influential groups are expecting immediate results. Those responsible for organizing these efforts should be on guard for the possible loss of direction when too many people are involved, a weakening of momentum and control of the process, the escalating complexity of local situations, and the danger of fostering unrealistic expectations among participants.

Despite these difficulties, the fact remains that only after substantial public interest is aroused can the hope of genuine civic engagement be realized. The consequences of broad public participation reverberate throughout a community and can profoundly influence the effectiveness of the policies adopted in pursuit of social and economic sustainability. A succinct summary of the critical value of civic engagement achieved through partnerships and other participatory mechanisms grounded in a viable public sphere is offered by Wolf (1999: 219-221):

> A whole sequence of benefits follows from citizen involvement, some direct, some not so obvious. When enough residents get involved, public officials become accountable.... In addition, involvement affords the committed individual a community presence. Not infrequently, the engagement reveals to individuals something new about their own vision and special interests.... A thoughtful citizen group is able to transform a citizen's naivete into genuine understanding. Voluntary networking forges links between people across the social, economic, and political spectrums. A free and open exchange of viewpoints from the bottom up is the opposite of citizen apathy, in which people complain of political impotence while idly watching shortsighted, top-down decisions diminish their town. As increasing numbers of residents become interested, community apathy gives way to learning, understanding, and widespread participation.... As they dedicate time and energy, they come to feel like—and to be—owners, stakeholders in the destiny of a place.

SUSTAINING CULTURAL IDENTITIES

The "destiny of a place" to which Wolf refers is the future phase of a historical process that unfolds in part through the evolution of a local *culture*—the shared complex of ideas, beliefs, values, and modes of expression through which people living in a locality or region such as the Missouri Ozarks understand and express the meaning of their lives. Culture is the fabric within which these elements are integrated to form a shared, more or less coherent worldview that serves as the unquestioned background for people's day-to-day experiences. As such, it profoundly influences how Ozark residents understand themselves, their communities, others from outside the region, and the natural setting in which they live. Sustaining culture is thus equivalent to sustaining a way of life within which individual and social identities are shaped, and it is thereby fundamental to any vision of quality of life as the goal of social sustainability.

How might the local culture of people living in a geographic region such as the Missouri Ozarks be described? Mumford (1970: 386) conveyed the essence of such a notion more than a half a century ago in one of the earlier discussions of the idea of regional development. In doing so he was actually describing the ingredients of a viable local culture as the basis for actions that would lead to sustaining local ways of life. In his view, genuine regional development would be that in which

> People will know in detail where they live and how they live: they will be united by a common feeling for their landscape, their literature and language, their local ways, and out of their own self-respect they will have a sympathetic understanding with other regions and different local peculiarities.

This suggests that a local culture integrates a sense of place with a perspective of living well with fellow humans in that place. In terms of the ideas discussed earlier, we would expect

that such a perspective would be grounded in a recognition of and respect for the status of an area's keystone resources. For the natural history of a place describes the evolution of a physical setting that people by their presence have transformed into *cultural landscapes*— and these, in turn, subsequently reflect both natural *and* social history as they coevolve through time. Cultural landscapes manifest the "ecological footprint" of humans (Wackernagel and Rees 1996); they convey across generations both their value as a distinctive local asset and, if tended with a responsible stewardship, an ecologically diverse setting in which to live. They may also reveal a history of accepted land management practices that have likely been fine-tuned over time in response to local conditions.[30] As well as producing a unique cultural heritage, which is essentially irreplaceable, these traditional practices may furnish exemplars for living sustainably by exhibiting responsible stewardship of an area's keystone resources. For as Norton (1999: 143-146) observes, "If families hope, for example, to remain in the region for generations, they will value these keystone resources as essential to maintaining the same range of opportunities for the next generation. When they think of their community in the long run—as a multigenerational, ongoing project—they will therefore see careful use of these primary, keystone resources as an investment that protects the core values of the community." When the pathway to sustainability is forged in this manner the region and its localities will indeed change, but they will grow upon a more resilient foundation.

Yet as Orr (1992: 31-32) argues, in today's world in which science and technology reign supreme, it is often overlooked that both ecological and socio-economic sustainability are "rooted as much in past practices, folkways, and traditions as in the creation of new knowledge." Appealing to the insights of Noorgaard (1987: 14) on the importance of local or traditional knowledge (see also, Geertz 1973), he notes that such knowledge "is location specific and only arrived at through a unique coevolution between specific social and ecological systems:"

> It is a source of community cohesion, a framework that explains the origins of things (a cosmology) and ... is not separated from the specific tasks of living well in a specific place over a long period of time. The crisis of sustainability has occurred only when and where this union between knowledge, livelihood, and living has been broken and knowledge is used for the single purpose of increasing productivity.

In short, local knowledge provides an important foundation for attitudes and value orientations toward forests and other keystone resources, as well as a respect for and appreciation of fellow residents shaping their futures in the same place. In this way it integrates nature as a partner with human endeavors.

From a cultural perspective, education represents a primary means by which knowledge, value orientations, and modes of artistic expression are passed on from generation to generation. Thus a sound institutional structure in education will be an important asset for any region or locality, both for local residents and as a basis for attracting new ones. As noted earlier, many Missouri Ozark counties have historically struggled to provide and maintain a highly educated populace (table 7.2), and such counties are frequently in the lower tier when judged by statewide indicators of educational performance. But as Wolf (1999: 210) observes, "A wise community will not just attract skilled [and knowledgeable residents], it will learn to grow its own." A focus on *lifelong education* recognizes the value of providing educational opportunities that start from an individual's early years and continue on even late in life. This can begin with policies that encourage innovative childcare programs, and by ensuring that a community's youth will be taught the economic, social, and ecological history of their

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[30]Of course, such landscapes may also bear the scars of boom and bust eras in which short-term economic concerns overrode those regarding the sustainability of keystone resources—a scenario characteristic of much of the Missouri Ozarks at the turn of the 20th century. Moreover, certain practices may become part of a local culture that are detrimental to sustaining keystone resources—e.g., woodland burning, running deer with dogs. Thus, while much of a local culture should be retained, the legitimacy and validity of various ideas and practices are continually reaffirmed or renegotiated across generations. In the process, some of these may come to be rejected or no longer actively endorsed.

community as part of grade and high school curriculums. Included here would be opportunities for young residents to learn about the inner workings of their own community and its relationship to the surrounding landscape. Options for community service could vitalize such curriculums even more. Such opportunities should continue beyond high school and college graduation as well. Adult education programs should be encouraged within schools and non-academic settings such as libraries, museums, religious institutions, and hospitals. These may include opportunities for continuous job retraining as careers evolve in response to the shifting employment patterns and job venues that have emerged with the new economy. A vibrant community will recognize that continuing education may be a form of economic renewal, cultural integration, or even recreation for many people and will treat it as an attractive and important service to community residents.

Religion and the arts are also avenues of expression through which people interpret life in a particular place. Religious congregations are an important source of a community's moral fiber; and an active religious community can not only promote important and socially cohesive values, but also serve as an example of putting those values into practice by providing a range of social services to community members, particularly those who are economically disadvantaged. A community's capacity for expressing the aesthetic sensibilities of living well in a particular place is most directly reflected in its residents who participate in or patronize the arts. Indeed, the Missouri Ozarks, with its rich tradition of folklore, music, crafts, and the like, is one of the most culturally distinctive areas of the State. A critical ingredient of the quality of life in any community, rural or otherwise, is the opportunity to enjoy art, music, literature, theater, and so forth—in short, the entire repertoire provided by cultural organizations.

Sustaining a viable atmosphere in which the arts can thrive is a challenging task, particularly for many rural communities struggling to provide a whole host of additional social services to their residents. Funding for the arts does, however, represent another potentially positive focus for public-private partnerships. Here the variety of innovative ways in which larger, older communities have financed arts-related development offers some helpful guidance to their smaller rural counterparts. Cooperative efforts among businesses, foundations, and individuals in the funding of non-profit cultural, recreational, and educational initiatives may often be facilitated by the municipality providing the land or low-cost financing to obtain the land. The creative use of schools and religious buildings as community resources can effectively sidestep the inclination of residents to oppose the local tax increases that would be needed to finance the construction of individual facilities for these purposes. A community can engage many of its young residents by supporting programs that encourage participation in the arts on an amateur level. This could be achieved both through school curriculums and independently sponsored programs. These and other types of informal cultural offerings are another indication of the vitality of a place and its inhabitants.

Finally, the family is the primary institution through which the culture of a society, region or locality is transmitted from generation to generation; and a community's range and effectiveness of *family services* is an important ingredient in its overall quality of life. In addition to those services that safeguard a basic level of economic security as part of a viable safety net for community residents, perhaps the greatest service a community can provide to its families with children is to enhance their primary role in transmitting the cognitive, moral, and expressive elements of a local culture to the generation of youth who will assume the role of active community citizens in the future. This assumes, of course, that some young people will wish to remain in their local community, or at least return to it after temporarily leaving to obtain a college education or other types of training not available locally. Stemming the drain of local youth in pursuit of more lucrative opportunities to make a living elsewhere is, however, one of the principal goals inherent in achieving the social and economic sustainability of any rural community; so few would claim that such a burden should be placed entirely, or even primarily, on the individual family.

Given the increasingly prominent role of women in the workplace, whether this reflects employment by necessity or by choice, both a community and its businesses can work together to promote family-friendly workplace policies. As Giddens (1998: 125-126) observes,

firms vary widely in the level of childcare they offer, and "not only childcare, but a variety of other opportunities to work at home can help reconcile employment and domestic life. The more firms that emphasize human resources, the more competition there will be to have the best family-friendly work environment." Public policies that encourage firms to adopt such attitudes via incentives and other innovative measures can help to soften the constraints of the workplace on the responsibilities of families towards the future well-being of both their own offspring and their community as a whole.

More generally, innovative policies toward the provision of social services essential to the quality of life in a community should take advantage of the reservoir of willingness among many community residents to look beyond themselves to the well-being of others—the lifeblood of social solidarity. For as Beck (1997: 106) observes, "More and more people are looking both for meaningful work and for opportunities for commitment outside of work. If society can upgrade and reward such commitment and put it on a level with gainful employment, it can create both individual identity and social cohesion." A start might be achieved by adopting a system of "shadow wages," or tax breaks for hours worked in the social economy. Regardless of the particular form that any of the numerous measures on a pathway to social and economic sustainability may take, much of the energy required to forge a sustainable quality of life—not only for residents of the Missouri Ozarks, but also for broader societies—is to be found within the individuals who make any community what it is through their quest for a meaningful life for themselves and their children.

THE CHALLENGE AHEAD

The preceding pages have presented a broad description of the complex terrain encompassed by the idea of social and economic sustainability based on the premise that the social relations people establish with one another both strongly influence and are influenced by how they perceive and interact with their natural environment. Sustaining that environment, of which the forest landscape of the Missouri Ozarks is a central component, is both a requisite for and consequence of the ability to effectively sustain the rich matrix of social and economic relations among Missourians who make the Ozarks their home.

While a number of potential options for moving closer to social and economic sustainability have been touched upon in the preceding pages, it is worthwhile to conclude with four basic actions—each reflecting an important dimension of social life among Ozark residents—that may together frame the most hopeful pathway to sustainability, whichever of its many shades we may wish to consider:

- Build a diverse economy anchored both in horizontal connections to broader economic systems and vertical linkages that ensure responsible local stewardship of an area's keystone resources.
- Establish an institutional structure of local and regional groups—formal and informal, with varying decisionmaking and advisory capacities—that residents can recognize and trust, and within which they can collectively shape a vision for the future of their community and mobilize the collective resources needed to make that vision a reality.
- Foster a vibrant level of civic engagement in all aspects of social life among Ozark residents that taps their willingness to view their own needs and interests as best realized in the very process of sustaining the communities and region in which they live.
- Protect and sustain the vitality of cultural landscapes that reflect the coevolution of natural and social settings in which the rich natural history of the Missouri Ozarks is blended with the cultural heritage of its people.

These few admittedly difficult but critically important steps would go a long way towards realizing—in the sense of both attaining and appreciating—a quality of life that is self-sustaining through its very acknowledgement of the social, the economic, and the ecological dimensions of sustainability as coevolving parts of a single vibrant system in which we find ourselves and seek our destinies.

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Sustainable Silviculture for Missouri's Oak Forests

W. Dustin Walter[1] and Paul S. Johnson[2]

In our way, with every decision we make, we always keep in mind the Seventh Generation to come. It's our job to see that the people coming ahead, the generations still unborn, have a world not worse than ours—and hopefully better. When we walk upon Mother Earth, we always plant our feet carefully because we know the faces of our future generations are looking up at us from beneath the ground. We never forget them.—Oren Lyons, Iroquois.

Think about it. You yourself are a Seventh Generation!—Leon Shenandoah, Iroquois. (Arden and Wall 1998)

INTRODUCTION

Human population growth and human consumption of forest products is straining the Earth's capacity to sustain healthy forests. Forests cover about one-third of Earth's land surface, which represents a shrinkage of about one-third since the rise of agriculture-based civilizations (Noble and Dirzo 1997). In the United States, a similar reduction has occurred over the last 400 years. U.S. forests now occupy about 70 percent of the area they covered in 1600 (fig. 8.1). On the positive side, the area of U.S. forests has remained relatively constant since 1920 (MacCleery 1993), and their general condition in terms of stocking, growth, and quality has greatly increased since 1952 (Powell *et al.* 1994). By their very existence, area, extent, and social and economic importance, these forests compel our attention to their sustainability.

The concept of sustaining forests to meet societal needs forms the foundation of the discipline of forestry. Forestry is defined as "the science, art, and practice of creating, managing, using, and conserving forests and associated resources for human benefit..." (Helms 1998). Although this discipline is several hundred years old, its role is often

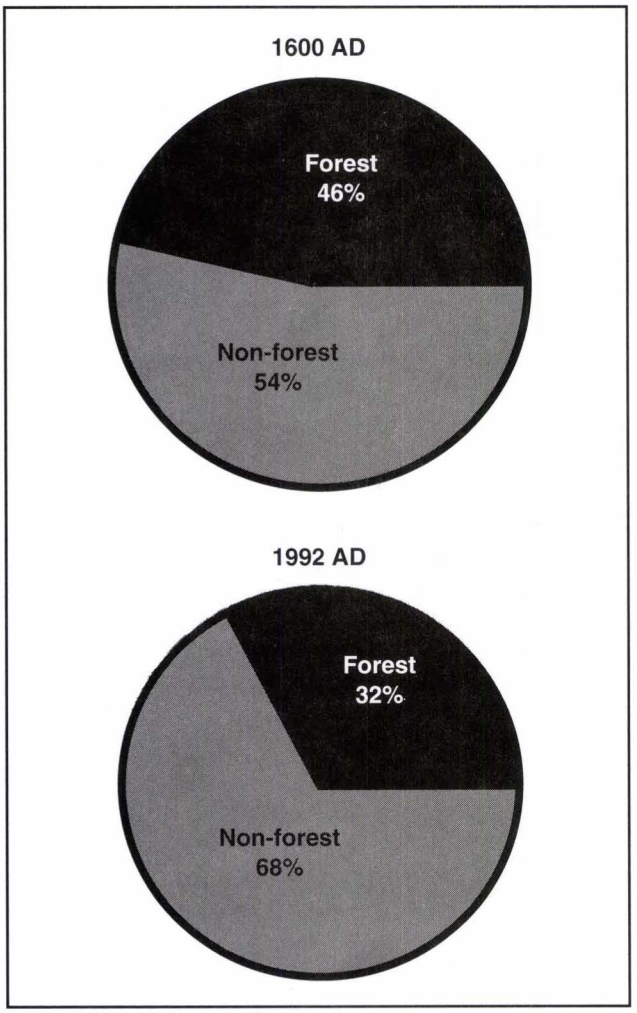

Figure 8.1-*Estimated proportion of the land area of the United States in forest and non-forest in 1600 and 1992. Actual forest acreage by year was 1,044 million acres in 1600 and 737 million acres in 1992; non-forest acreage was 1,219 million acres in 1600 and 1,527 million acres in 1992. Of the original forested area, about 70 percent is in forest today (from MacCleery 1993).*

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obscure or misunderstood in the public view. Forestry is also sometimes associated with exploitive practices because of its close association with the logging and timber industries. These perceptions persist despite an extensive scientific basis for contemporary forestry and a shift away from economic utilitarianism.

The concept of *sustained yield* ranks among the earliest and most important scientific principles of forestry. This is the "yield that a forest can produce continuously at a given intensity of management" (Helms 1998). Thus *forest renewability* is inherent in the idea of sustained yield. Under good forest stewardship, the same timber yields are theoretically sustainable to perpetuity. A problem with this concept is its one-dimensional focus on economic timber production as the primary forest resource. In response to contemporary social and ecological concerns, the sustained yield paradigm has been replaced by the broader concept of *forest sustainability.*

Forest sustainability is defined as "the capacity of forests, ranging from stands to ecoregions, to maintain their health, productivity, diversity, and overall integrity, in the long run, in the context of human activity and use" (Helms 1998). This definition alludes to our responsibility as stewards of the Earth to assure the quality of life for future generations. Living up to this ideal requires a multidisciplinary approach to forest management that transcends narrow single-discipline interests in defining what constitutes sustainability. This requires rejecting the idea that solutions to forestry problems are, or should be, exclusively technical and scientific. Accordingly, forest managers would no longer have exclusive control of forest management decisions. They would be required to interact with the public and professionals in related disciplines such as ecology, economics, and sociology. In this context, *sustainable solutions* presumably lie within a region of common agreement among potentially conflicting precepts of what is economically feasible, ecologically viable, and socially desirable (Salwasser *et al.* 1993).
It is in this context that this paper examines how humans can approach the sustainable management of Missouri's oak forests through silviculture.

MISSOURI'S OAK FORESTS

Missouri's oak forests are a part of the Central Hardwood Region, which includes the predominantly deciduous broadleaf forests of the Central United States (fig. 8.2). The region extends 1,200 miles from southwest to northeast. It covers approximately 220 million acres, about half of which now remains in forest. About three-fourths of the forested area in the Central Hardwood Region is owned by non-industrial private forest (NIPF) owners. Within that ownership, most holdings are 50 acres or smaller (Birch 1996). There are seven national forests in the region comprising about 4 million acres (Powell *et al.* 1994). They are distributed across the southern half of the region in Arkansas, Missouri, Illinois, Indiana, Ohio, Kentucky, and Tennessee. Of Missouri's 14 million acres of forest, 85 percent is in private ownership. Over half of this is in parcels smaller than 100 acres (Spencer *et al.* 1992).

About three-fourths of Missouri's forests are dominated by oaks (Spencer *et al.* 1992). Upland oak forests usually occur in mixture with flowering dogwood, blackgum, black cherry, red maple, shortleaf pine, and other

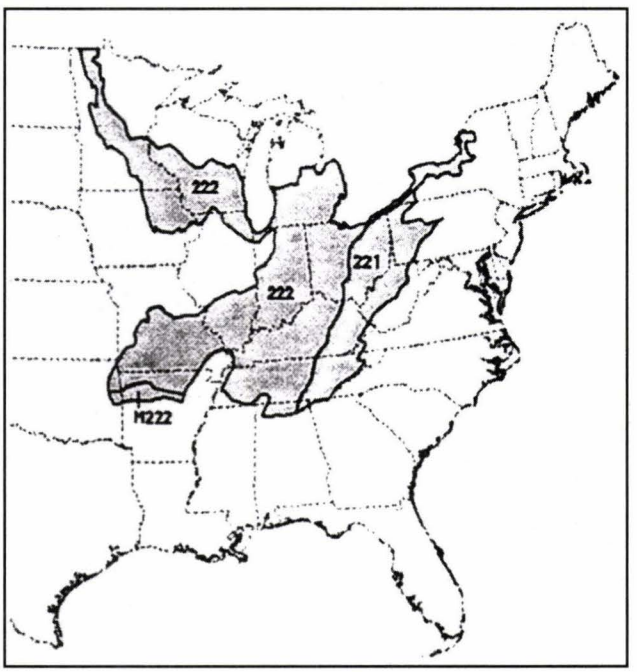

Figure 8.2—*The Central Hardwood Region (shaded area). Based on McNab and Avers (1994) ecological provinces and sections of the United States: (221) Eastern Broadleaf Forest (Oceanic) Province, exclusive of sections adjacent to the east coast; (222) Eastern Broadleaf Forest (Continental) Province; (M222) Ozark Broadleaf Forest-Meadow Province.*

upland species. The Ozark Highlands, which cover conterminous southern Missouri and parts of northeastern Oklahoma, northern Arkansas, and southwestern Illinois, comprise one of the most extensive and intact oak-dominated ecosystems of the world. Much of this forested area originated from canopy closure of extensive park-like oak savannas maintained by recurrent wildfires during the presettlement period (Johnson 1993a, Olson 1996).

Because of hickory's relatively constant presence in Missouri's upland forests, these forests are often referred to as oak-hickory forests. However, hickory seldom represents more than a small proportion of trees in the main canopy of a mature forest (Braun 1972). The oaks usually persist as the dominant members of stands. This persistence is facilitated by a natural regeneration dynamic that favors the accumulation of oak *seedlings* and *seedling sprouts* beneath the canopies of mature stands (Bey 1964; Johnson 1993a, 1993b; Merz and Boyce 1956). It is the resulting buildup of this reproduction, which can occur in the absence of fire or other disturbances, that distinguishes Missouri's oak forests from superficially similar forests in other ecoregions. Some of this pre-established reproduction develops large root systems through recurrent shoot dieback and sprouting (fig. 8.3). Many of the resulting seedling sprouts grow rapidly in height after natural or human-caused disturbances to the forest canopy that increase sunlight near the forest floor (Johnson 1979, Sander 1971). Such disturbances, combined with the oak's ability to sprout from the bases of cut or fire-killed trees, ensures the continued dominance by the oaks. Thus, it is through the formation of forest canopy gaps that the relatively shade-intolerant oaks naturally persist as the dominant species in Missouri's upland forests.

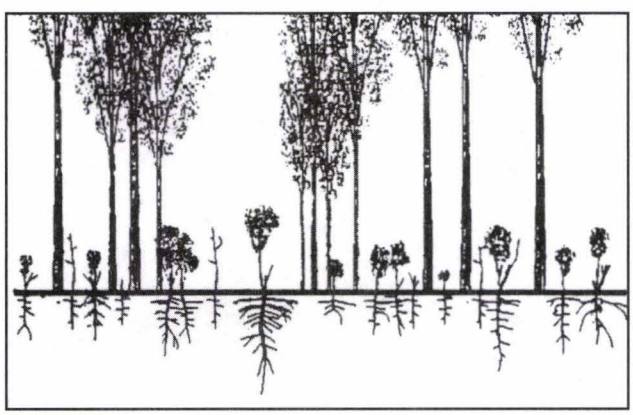

Figure 8.3—*Oak seedlings and seedling sprouts growing beneath a forest canopy. In Missouri oak forests, the shoots of oak seedlings usually die back one or more times to form "seedling sprouts." Some of these eventually develop large roots and thereby the capacity for rapid shoot growth when canopy gaps or large openings are created by natural or human-caused events.*

In Missouri oak forests, the reproduction of non-oaks such as hickory, black cherry, flowering dogwood, and blackgum (which are also pre-established) usually assume temporary dominance after heavy canopy disturbances. But within two decades the oaks usually re-emerge as the dominant species (Dey *et al.* 1996). Until another disturbance occurs, the non-oaks are largely relegated to the subcanopy or persist only as scattered members of the main canopy. Their short-lived dominance nevertheless is sufficient for them to complete their life cycles and to produce seed and new seedlings. Some species such as sassafras also regenerate from root sprouts. The entire arboreal complex thereby persists from one disturbance to the next as pre-established reproduction or as sprout-producing propagules originating from the roots and bases of overstory trees. The regeneration characteristics of oak-hickory forests confer great *ecological resilience* to these forests, i.e., the capacity to quickly return to their pre-disturbance state.

Closely associated with these oak forests are mixtures of oak and shortleaf pine. These forests often originate after fire. In the absence of further burning or other disturbances, the pines are eventually replaced by the more shade-tolerant oaks through the process of ecological succession. Despite their impermanence, oak-pine stands are important components of the landscape because of their role in maintaining both biodiversity and economic timber production (Cooper 1989, Kerpez and Stauffer 1989, Leopold *et al.* 1989, Phillips and Abercrombie 1987). Consequently, there is increasing interest in how to create and maintain this association (Waldrop 1989). In Missouri, the combined area of pine and oak-pine forest types has decreased by over 90 percent since 1880 (Cunningham and Hauser 1989). Most of the area lost to pine succeeded to oak forest. Forests dominated by eastern redcedar are also closely associated with the oak and oak-pine forests. This species is a common invader of old fields and glades (Lawson 1990). There, it may eventually form dense pure stands if succession is allowed to

progress unimpeded by disturbance. However, such stands are relatively short-lived. As the redcedar matures and forms canopy gaps, conditions become increasingly favorable for the invasion of the somewhat more shade-tolerant oaks and other hardwoods, which gradually replace the redcedar.

The utilization and exploitation of forests in the Central Hardwood Region has passed through various historical phases (Hicks 1997). Even before the arrival of Europeans in the early 1800s, the nature and extent of the region's forests were heavily influenced by humans (Whitney 1994). The intentional and accidental use of fire to control vegetation by Native Americans had a significant impact on the extent and character of presettlement forests (DeVivo 1991, Olson 1996, Pyne 1982). These human-caused alterations of the landscape continued for thousands of years before the arrival of Europeans (Hicks 1997). After European settlement, human exploitation of the forest further expanded and intensified. Burning, grazing, exploitive timber harvesting, and clearing of forests for agriculture occurred on an unprecedented scale.

The history of uncontrolled burning in Missouri forests ended about 50 years ago. Even before the Europeans arrived, Missouri's forests were frequently burned by Native Americans (Beilmann and Brenner 1951). Recent studies also link humans to fire in the Missouri Ozarks. An analysis of the annual rings of post oaks in a Missouri oak savanna showed that the frequency of occurrence and extent of fires were greatest between 1700 and 1810, a time when the average fire-free period was 4.3 years (Guyette and Cutter 1991). Although not every acre burned every year, the historical and scientific evidence indicates that the frequency, intensity, and extent of those fires significantly affected the ecology of the entire Central Hardwood Region (Abrams 1992, Grimm 1984, Hicks 1998, Pyne 1982). From a historical landscape perspective, it may be more accurate to regard the absence of fire as unnatural rather than natural. Fire potentially has its greatest impact on the regeneration of an oak forest. Although many young oak seedlings succumb to fire, in the longterm a disturbance regime that perpetuates fire tends to favor the oaks.

SILVICULTURAL PRINCIPLES AND THEIR APPLICATION TO MISSOURI OAK FORESTS

Silviculture is the art and science of tending, harvesting, and regenerating forests and involves an array of methods to achieve specific objectives. *Stands* are the objects of silviculture, i.e., the spatial units of a forest that receive silvicultural treatment. Ideally, a stand comprises a relatively homogeneous area with respect to vegetation, soil, and site quality. Its boundaries are usually circumscribed by landscape features such as streams, ridgetops, and roads. A *managed forest* is therefore usually comprised of numerous stands that are collectively managed to best meet the objectives of the landowner. These objectives are not necessarily limited to a single forest use. For example, timber production objectives may be combined with wildlife and aesthetic objectives.

The practice of silviculture in the Central Hardwood Region dates back to the genesis of North American forestry in the late 19th century (Fernow 1911, Pinchot 1987). From then until the 1960s, the major emphasis was on uneven-aged silviculture (Roach 1968). During the 1960s, the emphasis shifted to even-aged silviculture, especially clearcutting, which persisted for about 20 years (Johnson 1993a, Roach and Gingrich 1968). Through both eras and to the present, the predominant methods of timber harvesting in *unmanaged stands*, which comprise most of the region's forests, have probably been commercial clearcutting and other forms of indiscriminate timbering often collectively referred to as "highgrading." Not to be confused with silviculturally designed methods, the latter consist of harvesting only trees of high commercial value without regard to regeneration needs, future stand condition, or the sustainability of defined values. Such malpractice typically produces forests of highly variable residual stocking often comprised of trees of poor vigor, quality, and species composition. These practices persist and continue to negatively impact the quality of the region's forests. Yet the annual growth of trees in the Central Hardwood Region currently exceeds annual harvest, and standing volumes of trees are at their highest since 1952 (Powell *et al.* 1994).

Probably only a small fraction of Missouri's oak forests have received sustained, systematic silvicultural treatment. This may in large

part be related to the pattern of forest ownership, which is characterized by a large number of small non-industrial private forests. Private forest owners often lack information on the benefits from, or are uninterested in, applying silviculture (Bliss *et al.* 1994, 1997; English *et al.* 1997). Consequently, the systematic application of silviculture has largely been limited to publicly owned lands. There, hardwood silviculture usually follows the "ecological model," which is based on relatively *extensive methods of management* limited to the manipulation of existing natural vegetation and propagules. Accordingly, silvicultural methods focus on periodic timber harvests designed to control stand density, structure, composition, and most importantly, the regeneration processes that ultimately sustain the forest. Energy expenditures are largely limited to the extraction of biomass. Potential economic returns on investment are characteristically low to moderate. This approach contrasts with the "agronomic model," which is based on relatively *intensive methods of management* that rely on artificial regeneration, introduction of "improved" genotypes, use of herbicides and fertilizer, prescribed burning, use of exotic plants, or other intensive cultural methods such as those used in intensive plantation management and agroforestry. Relatively large energy expenditures result from both biomass extraction and cultural inputs. These costs are justified by potentially large economic returns resulting in part from a reduced production period.

The objectives of an ecologically based silviculture are to ensure, as best we know how, the sustainability of forests and defined forest values through the application of practices that are consistent with a forest's natural ecological dynamic and potential. Objectives may include, singly or in combination, economic timber production, aesthetics, wildlife, water quality, biodiversity, and other values. Silvicultural methods fall into one of three categories: even-aged, two-aged, or uneven-aged. Because the application of two-aged silviculture is relatively uncommon, the following discussion focuses on even- and uneven-aged methods.

Even-aged Silviculture

Even-aged stands are comprised of trees of a single age class. In Missouri oak forests, this usually means that the ages of trees within a stand differ by no more than about 20 years. This implies that even-aged stands are periodically renewed, or "regenerated," at specified intervals. A managed even-aged stand accordingly has a defined beginning and ending. It ends with a final harvest that removes all or most of the overstory, which simultaneously initiates a new stand. The length of time between stand regeneration and final harvests is the *rotation* (fig. 8.4A). Throughout a rotation, stand structure (i.e., the spatial arrangement of trees in the vertical plane) is continually changing. These changes are associated with changes in the diameter distributions of trees and sometimes species

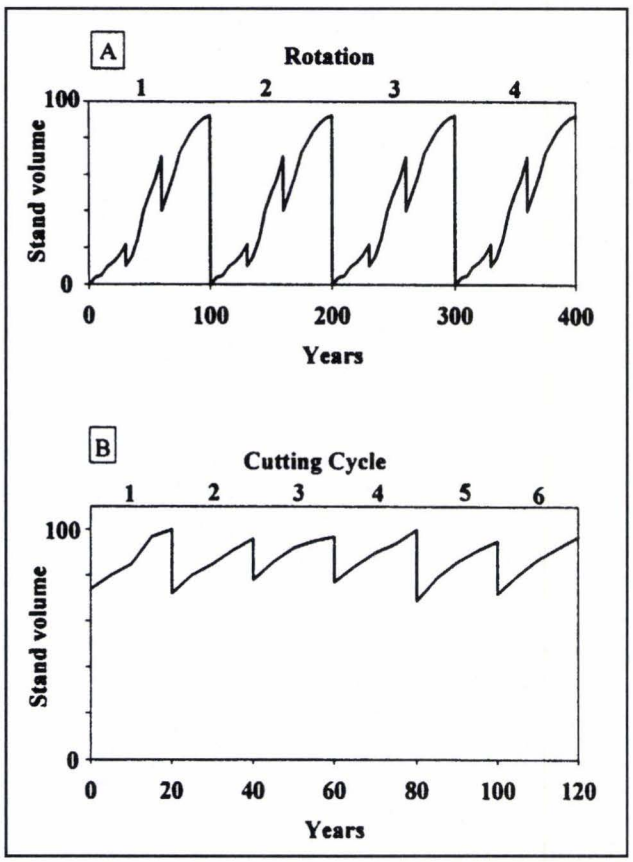

Figure 8.4—*Change in relative volume of merchantable trees in managed even-aged and uneven-aged stands. (A)* Even-aged stands *are managed on rotations. Intermediate cuttings are made between the beginning and end of the rotation. At the end of a rotation, the stand is usually completely harvested. During the life of an even-aged stand, stand structure is continually changing. (B)* Uneven-aged stands *are managed on cutting cycles, which define the length of time between harvests. Periodic harvests typically remove 25 percent or less of standing volume. Stand structure remains relatively constant across cutting cycles once the desired structure is attained. At the end of each cutting cycle, trees are harvested across a wide range of diameters. Both methods of management theoretically produce sustained yields.*

composition. During the period between regeneration and final harvest, stands are "tended," i.e., various silvicultural methods such as *thinning, pruning,* and *releasing* of selected overtopped trees from suppression may be applied. Trees removed in thinnings, also called *intermediate cuttings*, are predominantly those that are poorly formed, overtopped by other trees, or at high risk of dying before the next thinning is made. This ensures continual improvement in the quality and economic value of the stand.

In applying even-aged silviculture to Missouri oak forests, adequate reproduction (seedlings and seedling sprouts) must be pre-established in the understory before the overstory is removed. Complete overstory removal then creates conditions favorable for the growth of the reproduction. Two even-aged silvicultural systems that have been widely applied to Missouri oak forests are the clearcutting and shelterwood methods.

The Clearcutting Method

Clearcutting is a regeneration method that completely removes the overstory in a single harvest at the end of the rotation. This involves cutting all trees down to 2 inches in diameter at breast height (d.b.h.). However, the method can be modified to leave a few "reserve" trees per acre to accommodate non-timber objectives such as preserving aesthetic values, acorn producers, and trees with den and nest cavities. Whatever secondary objectives there are, the primary reason for applying the method is to harvest and regenerate the stand in one operation. After overstory removal, full sunlight promotes the rapid growth of the pre-established oak reproduction.

Despite its economic efficiency and technical efficacy, clearcutting has not received public acceptance. Clearcuts are commonly perceived as ugly, and are believed to accelerate soil erosion and runoff and to increase stream sedimentation. Probably no other silvicultural practice has received more public condemnation than clearcutting. This social reaction to clearcutting, in turn, led to the widespread abandonment of clearcutting in favor of uneven-aged silvicultural methods. Ironically, clearcutting's rise to prominence during the late 1960s and 1970s began with dissatisfaction with uneven-aged silviculture.

Disappointment with single-tree selection, combined with early regeneration successes with clearcutting, ushered in the clearcutting era in the Central Hardwood Region in the 1960s. The practice was reinforced by the seminal publication *Even-aged Silviculture for Upland Central Hardwoods* by Roach and Gingrich (1968). This publication represented a synthesis of years of even-aged silvicultural research and experience. The shift from uneven-aged to even-aged silviculture thus was not born of inexperience with alternative silvicultural systems or of the absence of a scientific basis for the technical efficacy of even-aged silviculture. Clearcutting was enthusiastically accepted by silviculturists for several reasons. In the Central Hardwood Region, it met the ecological requirements of the commercially valuable, shade-intolerant species, including the oaks, white ash, black cherry, and yellow-poplar. Clearcutting was also economically efficient. Logging, road building, and administrative costs were minimized because large timber volumes could be harvested from relatively small areas. Other factors contributing to the acceptance of clearcutting among forest managers included its endorsement by wildlife biologists, the development of even-aged stocking guides and prescriptions for its application (Gingrich 1967, Roach 1977, Roach and Gingrich 1968), the simplicity of creating balanced distributions of stand age classes, and other advantages (McGee 1987).

Clearcutting thus became the most widely recommended and applied regeneration method in the region, albeit with mixed success in oak forests. In oak forests, it was most successful in the drier ecosystems such as the Ozark Highlands of Missouri. There, the method's success coincided with the presence of large pre-established oak seedling sprouts (Johnson 1993a, Sander 1971, Sander and Clark 1971, Sander *et al.* 1984). The method was less successful in regenerating oaks in the more productive ecosystems of the Ohio Valley, Appalachians, and elsewhere (Beck and Hooper 1986, Gammon *et al.* 1960, Johnson 1976, Loftis 1983). Even there, other commercially valuable species usually replaced the oaks. Clearcutting nonetheless often accelerated the succession of oak-dominated stands to stands with less oak or no oak (Abrams and Downs 1990, Abrams and Nowacki 1992).

The rise of environmental activism in the 1970s focused public attention on real or perceived negative consequences of clearcutting, including diminished aesthetic value, biodiversity, old growth, certain wildlife values, and soil and water values. Perhaps no clearcutting issue has been more exaggerated than that of soil erosion. Although improper timber harvesting practices can increase soil erosion, soil losses from erosion can be held close to natural loss rates by using simple logging and road management guidelines (Haussman and Pruett 1978; Kochenderfer 1970; Patric 1977, 1978). Research in the Appalachian Mountains of West Virginia has has shown that annual soil erosion losses from forests range from 0.05 to 0.10 tons per acre per year for both undisturbed and clearcut forests (Patric 1976). This can be compared to "acceptable" rates of soil loss from agricultural lands, which range from 1 to 5 tons per acre per year (Patric 1977). Even when erosion rates associated with clearcutting exceed normal levels, they usually return to pre-harvest rates within 2 to 3 years after harvesting (Patric 1977). As Mills and others (1987) pointed out, "farmland is usually cultivated annually, while managed forestland is usually not logged more than once every 10 to 20 years." Similar exaggerated but unjustified claims about the negative consequences of clearcutting have been made in regard to stream sedimentation, stream water quality and temperature, streamflow, flooding, and nutrient discharge (Mills *et al.* 1987).

To counter the numerous concerns, clearcutting was modified in various ways: size of clearcuts was reduced; snags, cull trees, and uncut islands of trees were retained to enhance wildlife and aesthetic values; the removal of non-commercial residual trees was deferred; cuts were shaped to fit more aesthetically into the landscape; and uncut strips were left where clearcuts bordered roads, lakes, streams, and other sensitive areas (Evans and Conner 1979; Smith *et al.* 1989; U.S. Department of Agriculture, Forest Service 1973, 1980). Despite these modifications, clearcutting continued to fall into public disfavor. The public demanded systems that focused less on producing commodities and more on preserving aesthetics, biodiversity, and other values (Gale and Cordray 1991, Hansen *et al.* 1991, Kessler 1991, Perry and Maghembe 1989, Salwasser 1990). Attitudes toward clearcutting nevertheless may be more complex than commonly realized. For example, in a survey of NIPF owners in the Mid-south, nearly half of the respondents considered clearcutting to be an acceptable practice on NIPF lands, whereas only 14 percent considered the practice acceptable on government-owned lands (Bliss *et al.* 1997). With respect to its application on private lands, a significantly larger proportion of college-educated respondents (52%) considered it an acceptable practice than did less educated respondents (42%). Moreover, the responses of NIPF owners were similar to those of the general public (Bliss *et al.* 1994).

Despite the "technical correctness" of clearcutting as a solution to a regeneration problem, the solution itself produced unanticipated social and political consequences. One outcome was the Monongahela Decision of 1970, which imposed uneven-aged silviculture as a primary management tool on the Monongahela National Forest. The decision reinforced organized intervention by the critics of clearcutting, which resulted in a major reduction in its application on all national forests. But it also had a wider effect. As Hicks (1997) noted: "It imposed the will of the public over that of foresters, who had always been regarded as the experts in forest resource management." The solution to an innocent silvicultural problem thus spiraled into the more profound problem of determining who plays a legitimate role in planning the use of public forests.

The clearcutting controversy has demonstrated that solutions to silvicultural problems are likely to transcend the exclusively scientific and technical approaches familiar to foresters. Silviculture and other forestry practices now are features of the political landscape. Foresters (especially those managing public lands) no longer have exclusive control of their domain. They now must engage in public dialog on diverse and often competing forest uses. Effective dialog requires recognizing and considering widely differing perspectives of *forest values*, some of which may be anathema to traditional forestry theory and practice. The emergence of this *value-centered debate* has precipitated a profound change in silvicultural practice: the replacement of the economically focused *sustainable timber yield* paradigm by the ecologically centered *sustainable forest* paradigm. However, it may not be the abandonment of clearcutting that characterizes the new paradigm as much as it represents a search for a wider range of methods for meeting

unprecedentedly diverse social, economic, and environmental demands.

The Shelterwood Method

The shelterwood system involves the gradual removal of the overstory through a series of partial cuttings near the end of the rotation (Smith 1986). The objective is to encourage the establishment and growth of reproduction before the final harvest is made. In the *uniform shelterwood method*, the overstory is completely removed in two to three cuts. The *strip shelterwood method* is applied in strips across the entire stand. Another variant of the method involves removing trees in groups or patches and is accordingly called the *group shelterwood method*. The *irregular shelterwood method* extends the regeneration period longer than usual by deferring the final harvest and sometimes increasing the number of shelterwood cuts. If retained long enough, the shelterwood may temporarily produce a two-tiered, two-aged stand. The method accordingly can be flexibly applied to manipulating overstory density in time and space. This flexibility is potentially useful in establishing the relatively shade-sensitive oaks (Beck 1991, Hannah 1987, Jacobs and Wray 1992, Korstian 1927, Sander 1979, Scholz 1952, Smith 1986).

Its potential notwithstanding, the shelterwood method has not been consistently successful in regenerating oaks (e.g., Martin and Hix 1988, Schlesinger *et al.* 1993, Walters 1990). On highly productive sites where oak reproduction is competitively disadvantaged, some have proposed coupling the method with prescribed burning (Brose and Van Lear 1998). This is consistent with the theory that burning promotes the buildup of populations of large oak seedling sprouts (Johnson 1993a, 1993b). Oaks are well adapted to surviving fire because they have dormant buds that are often an inch or more below the soil surface where they are protected from lethally high temperatures (Korstian 1927). The shelterwood method also can be combined with oak planting. In the Ozark Highlands, planted oaks survive well under shelterwoods and grow rapidly after final shelterwood removal (Weigel and Johnson 1998a, 1998b).

Despite recent advances, most applications of the shelterwood method suffer from the same criticism as clearcutting, i.e., regenerated stands look much like clearcuts after the shelterwood is removed. Perhaps, as Murphy and others (1993) suggested, the method suffers from a "guilt of association" with other even-aged methods. The method is nonetheless potentially flexible because shelterwoods can be retained, at least hypothetically, until a two-aged stand develops (Beck 1991, Smith 1986). In theory, a shelterwood can be removed in steps that are so gradual that eventually the regenerated stand developing beneath it grows up and becomes indistinguishable from the shelterwood before the latter is completely removed. The resulting *irregular shelterwood* thus may have more aesthetic appeal than the regular shelterwood or clearcutting methods.

The irregular shelterwood method also may be compatible with managing oak forests for acorn production. Acorns are important to numerous wildlife species. They are highly nutritious and available during the critical fall and winter months when other wildlife food is scarce. The population and health of many wildlife species consequently rise and fall with the cyclic production of acorns (Healy 1991, Pfannmuller 1991). However, only a relatively small proportion of oaks within a stand are inherently good acorn producers. Sustaining high rates of acorn production therefore requires identifying and retaining good acorn producers for as long as possible (Johnson 1993a, 1994). In principle, the irregular shelterwood method can be used to retain good acorn producers until acorn production from the regenerated stand occurs or is close to occurring.

Uneven-aged Silviculture

Uneven-aged silviculture requires the application of the selection system. By definition, an uneven-aged stand is one comprised of at least three age classes of trees closely intermingled on the same area (Smith 1986). Stands are managed on a *cutting cycle* rather than a rotation. A cutting cycle is the number of years between partial cuts. In oak forests, cutting cycles typically range from 10 to 20 years. They are usually shorter in highly productive stands than in less productive stands. A proportion of the merchantable volume of each stand is harvested at the end of each cutting cycle and the overstory is never completely removed (fig. 8.4B). There is no rotation in uneven-aged silviculture.

The guiding principle in the application of uneven-aged silviculture is the creation and maintenance of the uneven-aged state. Moreover, this state should recur at a relatively small spatial scale (e.g., < 1 acre). The associated silviculture is designed to maintain a three-tiered forest canopy comprising an overstory, a midstory, and a sapling/reproduction layer associated with the uneven-aged state. However, the ideal uneven-aged stand is made up of many age classes. Associated diameter frequency distributions are diverse and may range from very irregular (*unbalanced*) distributions to relatively smooth reverse J-shaped (*balanced*) distributions (fig. 8.5).

There are two options in applying uneven-aged silviculture: the single-tree selection method and the group selection method. Both methods are applicable to Missouri oak forests.

The Single-Tree Selection Method

As the name implies, single-tree selection involves harvesting selected individual trees at the end of each cutting cycle. Such harvesting usually creates small canopy gaps the size of individual trees. In practical application, somewhat larger canopy openings are sometimes created when dead or dying trees are removed in small groups. In any case, a relatively closed-canopy forest is maintained. Stand structure, density, composition, and regeneration are controlled by removing trees across a wide range of diameters at each harvest. This contrasts with the widely held belief that only the largest and oldest trees are or should be removed. Sustaining the uneven-aged state requires the creation and maintenance of a relatively balanced diameter distribution (fig. 8.5). It is only through maintaining a balanced diameter distribution that sustaining the uneven-aged state with a high degree of certainty is possible. Although it is possible to manage uneven-aged stands with unbalanced diameter distributions, we have no established ecological theory or silvicultural technique to effectively predict or control the future state of uneven-aged stands with unbalanced diameter distributions. It is not uncommon for oak stands with unbalanced diameter distributions to drift toward the even-aged or two-aged state after a few cutting cycles (Roach 1968). To the extent that sustaining the uneven-aged state is an important management goal, creating and maintaining a balanced diameter distribution is an essential feature of sustainable uneven-aged silviculture.

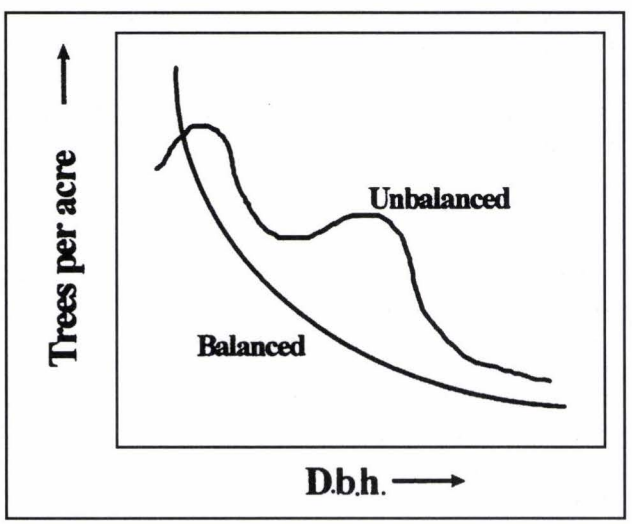

Figure 8.5—*The diameter distributions of uneven-aged stands can assume many different shapes. A relatively smooth reverse-J shape comprises a "balanced" and silviculturally sustainable distribution. "Unbalanced" (or irregular) distributions can assume innumerable shapes and may not be sustainable. Sustaining the uneven-aged state with a high degree of certainty requires maintaining a balanced diameter frequency distribution.*

Controlling stand density is another keystone in sustaining uneven-aged stands. At the end of each cutting cycle, stand density is reduced by timber harvesting. These harvests not only maintain high growth rates of the residual stand, but also are critical to sustaining the recruitment of oak reproduction into the overstory. In turn, periodic recruitment of reproduction is essential to sustaining the growth of trees into successively larger diameter, and correlatively, maintaining a balanced diameter distribution. A balanced diameter distribution can be thought of as a pipeline along which trees move from one diameter class to another with the reproduction entering at the beginning of the pipeline. However, only a proportion of trees in each class ever become members of the next larger class. Typically, from 10 to 30 percent of trees never grow into the next larger 1-inch diameter class. In a managed stand, this results from the combined effects of natural mortality and timber harvesting. In an unmanaged stand, approximately the same loss of trees occurs entirely from natural mortality. Timber harvesting therefore captures a portion of periodic tree growth that would otherwise be lost to mortality.

In Missouri oak forests, stands must be sufficiently reduced in density to effect a "pulse" of growth of oak seedlings and seedling sprouts into the overstory following each reduction in stand density (fig. 8.6). These pulses occur after each partial harvest, which periodically reduces stand density to levels that reinforce the continued buildup of oak reproduction (Larsen *et al.* 1997, 1999). Assessing the sustainability of the system requires periodically inventorying the entire uneven-aged forest. This facilitates determining whether the uneven-aged state and other values are being sustained. But reasonable assurance of sustainability is only realizable after several cutting cycles.

Experience in applying the single-tree selection method in the oak forests of the Missouri Ozarks indicates that the method is sustainable if stand density is reduced to 50 to 55 percent stocking at least every 20 years. The method requires removing trees down to at least 10-inches d.b.h. based on appropriate guiding curves that maintain a reverse J-shaped diameter (d.b.h.) distribution (Larsen *et al.* 1999, Loewenstein 1996, Wang 1997). The method's success is largely attributable to the natural oak regeneration dynamic of Ozark oak forests, which is characterized by the accumulation of oak reproduction beneath the parent stand. This accumulation is reinforced by the periodic reduction in stand density (Larsen *et al.* 1997). Adequate regeneration ensures the requisite recruitment of reproduction into the overstory, which in turn maintains the reverse J-shaped diameter distribution of oaks necessary for systematically sustaining the uneven-aged state. The presence and persistence of white oak, which in this ecosystem tends to naturally form a reverse J-shaped diameter distribution, is also conducive to the method's successful application. The method may be applicable in other regions where oak forests possess similar oak regeneration dynamics and stand structure.

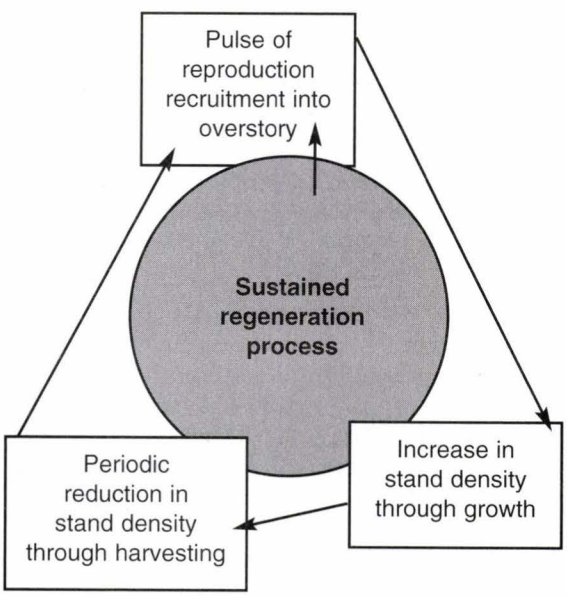
Pulse of reproduction recruitment into overstory
Sustained regeneration process
Increase in stand density through growth
Periodic reduction in stand density through harvesting

Figure 8.6—*Successful application of uneven-aged silviculture requires sustaining the regeneration process. Tree reproduction must grow into the overstory at frequent intervals to compensate for losses to natural mortality and periodic harvesting. In Central Hardwood forests, the pulsed recruitment of pre-established reproduction (seedlings and seedling sprouts) into the smallest diameter class comprising the overstory occurs after each periodic harvest and reduction in stand density.*

Due in part to the lack of social acceptance of clearcutting and its widespread and often indiscriminate application, the single-tree selection method has regained some of its former prominence in the Central Hardwood Region. It preserves some of the characteristics of older, undisturbed forests by maintaining large trees, a more or less continuous crown cover, and minimal logging slash. It therefore maintains the visual appearance of a more or less "natural forest" minimally affected by humans. The method is nevertheless widely misunderstood. It is commonly, but mistakenly, perceived as requiring only the harvest of mature trees. On the contrary, sustaining the uneven-aged state with a high degree of certainty requires harvesting trees across a wide range of diameters. In turn, this must maintain a balanced diameter distribution that is consistent with a stand's natural dynamic (Law and Lorimer 1989, Roach 1974, Smith 1986). Although there is evidence that uneven-aged silviculture in oak stands works in Missouri (Larsen *et al.* 1997, 1999; Loewenstein 1996; Wang 1997), its application to oak stands in other ecoregions has been less successful (Gingrich 1967; Roach 1962, 1968). In the mixed mesophytic forests of the Ohio Valley and Appalachians, the method usually results in the eventual displacement of the oaks by more shade-tolerant species (Mills *et al.* 1987, Roach 1963, Sander 1977, Smith and Miller 1987).

The Group Selection Method

In the group selection method, a portion of the stand is regenerated at the end of each cutting cycle by making a series of small canopy openings. In Missouri oak forests, the method is potentially useful for creating an uneven-aged stand structure where such structure does not already exist. As in the clearcutting and shelterwood methods, success in applying the method largely depends on the adequacy of the reproduction present at the time an opening is made. Recommended size of openings generally ranges from one to two times the height of the adjacent trees (Law and Lorimer 1989, Smith 1986). In Missouri forests, this criterion normally creates openings ranging from about 0.1 to 0.5 acres.

Some have argued that size of group openings should be designed to meet specific management objectives. For example, opening size can be determined by the area influenced by edge effects or "influence zones" (Bradshaw 1992). Influence zones may vary in size depending on the factors of interest or concern being influenced. There is a potentially long list of such factors. These include the formation of new branches on the lower boles (epicormic branches) of trees bordering openings, which can reduce their quality and economic value. Other factors include the growth of tree reproduction within openings (which tends to be depressed near the edges), post-harvest dispersal of acorns by birds and mammals into openings, brood parasitism and predation of nests of forest interior birds outside of openings, and other factors (fig. 8.7).

Although hardwood silviculturists have traditionally been most concerned with the effects of the number and size of group openings on regeneration and epicormic branching of trees on the periphery of openings, contemporary applications may require considering other possible consequences. For example, there is evidence that large numbers of small openings in forest canopies may reduce populations of certain migrant birds by increasing the predation of their nests and broods (Gustafson and Crow 1994, Thompson *et al.* 1993). Also, in mixed mesophytic forests in the Ohio Valley, the method has not proven effective in regenerating the oaks (Weigel 1994, Weigel and Parker 1997).

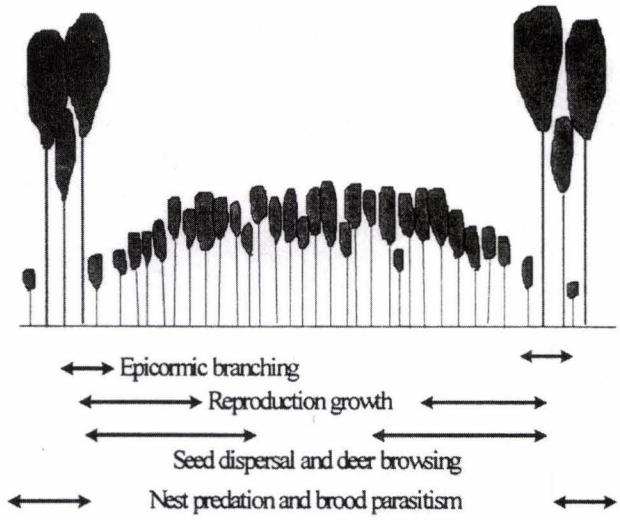

Figure 8.7—*Some potential edge effects associated with group openings in Missouri oak forests. Arrows represent potential influence zones associated with various factors (from top to bottom): epicormic branching of trees in the residual stand, growth of tree reproduction, post-harvest seed dispersal by animals and browsing of tree reproduction by deer, and nest predation and brood parasitism of songbirds. (Adapted from Bradshaw, 1992.)*

CONCLUDING THOUGHTS ON SUSTAINABLE SILVICULTURE

Silviculture provides us with methods for manipulating the structure and composition of stands of trees. By themselves, these methods are neither inherently good nor bad. In the context of sustainability, the efficacy of a forest management system (including its silvicultural components) is best defined by its ability to create and sustain the desired ecological states across a forested landscape. Is silviculture up to fulfilling its role in meeting the broad range of today's societal demands on forests?

Forestry is in the process of moving away from the ruling theory of *sustained yield* and toward the paradigm of *sustainable forests*. This change is largely in response to contemporary social and ecological concerns that transcend the narrow economic interests of sustained yield's European architects of 200 years ago. Today, the word "forest" obtains its fullest meaning through attached social values, which themselves are diverse and often conflicting. Social values, in turn, may conflict

with ecological knowledge and economic interests. *Sustainable solutions* to forestry problems thus lie within the region of common agreement of competing interests. The challenge to contemporary forest managers is to define this region and accordingly redefine forestry.

Because the term "forest sustainability" is an abstraction, its definition is likely to vary from one person to the next. This inconsistency arises from two sources. One source is the absence of a defined goal that specifies the ecological state (or states) to be sustained. Definitions accordingly reflect the perspective from which the forest is viewed. According to Allen and Hoekstra (1994), "Sustainability must always involve a chosen perspective if it is to be meaningful." The second source originates from the lack of a generally agreed upon definition of sustainability. Does it mean never changing? Allen and Hoekstra remind us that "in all healthy biological functioning, things persist and grow because other things are not sustained, as when prey succumbs to predator." Growth, nutrient cycling, regeneration, tree death, and disturbance are thus all facets of a forest's evolved strategy for self-maintenance and renewal. Some of those attributes, by themselves (e.g., tree death and disturbance), may even appear to contradict sustainability. However, the collective properties of a forest make up a dynamic whole that is continually changing. Forests therefore change with or without human involvement.

The existence of any given ecological state is therefore of limited duration. For example, the "pulsed" recruitment of trees into the overstory of an uneven-aged oak stand represents a recurring ephemeral event that is determined and constrained by the frequency and intensity of canopy disturbance (fig. 8.6). This produces a seeming contradiction, i.e., relative constancy at one spatial scale (e.g., the maintenance of a standwide or forestwide uneven-aged state) requires recurrent inconstancies at another imbedded scale (e.g., the ebb and flow of oak seedling sprouts into the overstory). In reality, such inconstancies *enable* sustainability. *Sustainable silviculture* therefore requires an understanding of ecological inconstancies and a synchronizing of silvicultural practices around them. A related misconception is the assumption that forest sustainability is ideally obtained in a pristine setting. However, humans have impacted forests on every continent where they naturally occur (Noble and Dirzo 1997). So even if forest sustainability became a universal goal, it probably would not emphasize the pristine. Forest management nonetheless should be consistent with the natural ecological order, and this may require including natural areas within the forested landscape that are allowed to develop free from direct human interference. These complexities pose questions about the practical application of sustainable forestry and the possible existence of models for its implementation.

In Missouri, examples of the application of sustainable forestry can be found on private, Federal and State forests. For example, a 150,000-acre privately owned forest in the Ozark Highlands has been successfully managed for over 40 years using the single-tree selection method (Larsen *et al.* 1997, Loewenstein *et al.* 1995, Loewenstein 1996, Wang 1997). The management objectives are to sustain a relatively continuous forest canopy while preserving structural and species diversity. The forest is periodically inventoried to ensure that objectives are met. On the Mark Twain National Forest, management follows legally mandated guidelines that require appropriate application of an array of silvicultural methods ranging from even- to uneven-aged. The Mark Twain also includes wilderness preserves, recreational areas, and areas where endangered fire-dependent habitats such as oak savannas and glades have been restored through controlled burning. The application of even-aged methods creates and maintains some of the forest in early states of succession, which are essential to some wildlife species (Thompson and Dessecker 1997). Stands under uneven-aged management and wilderness or natural areas provide the late-successional forests important to wildlife that depend on acorns and other heavy mast, tree cavities and dens, and the forest-interior habitats required by certain songbirds (Annand and Thompson 1993, Goodrum *et al.* 1971, Healy 1991, Pfannmuller 1991, Robinson *et al.* 1995, Thompson *et al.* 1997, Titus 1983). This landscape approach to forest management is complemented by an ecological classification system that provides a basis for deciding which management practices are best suited to a given area. An important objective is to sustain biodiversity at the landscape scale.

Similar management strategies are employed on State-owned forests, where providing for timber, wildlife habitat, and recreation go hand in hand. These examples provide models for the application of sustainable forestry to other forest lands in Missouri. There is a need for greater application of sustainable forest management practices to the 85 percent of Missouri's forests held by NIPF owners.

Other models of forest sustainability are provided by practices in Finland and in Menominee tribal forests in Wisconsin. Both nations have a dual forest management objective: sustaining timber yield while maintaining biodiversity. Both models depend on continuous forest monitoring and the application of silvicultural prescriptions consistent with maintaining and preserving the natural ecological order of the forest.

The Finns have made their living from the forest throughout their history. Today, forest products account for 40 percent of the value of Finland's exports (Parviainen 1994). These products originate from forest lands that are largely in private ownership. Nationwide, annual growth of forests now exceeds harvest. But 50 to 75 percent of Finland's forests had been devastated by shifting cultivation at the turn of the century. This led to changes in forest policy and silvicultural practices so that silviculture is now tailored to sustaining a diversity of ecosystem types. Although management is intensive, two-thirds of the 0.8 percent of Finland's annual forest regeneration is based on natural methods rather than planting. Management has evolved to include maintaining stands of mixed species, thinnings designed to mimic natural disturbance cycles, and preserving old-growth forests for endangered species habitat. The Finns also recognize the need to pay closer attention to ecological indicator species in forest monitoring, meeting the growing demand for forest recreation, maintaining adequate levels of down and dead wood, preserving ecological corridors, and using controlled burning to maintain fire-dependent species (Parviainen 1994).

The Menominee experience in timber harvesting dates back to 1854. Today, the tribal forestry philosophy is based on the concept of long-term, sustained-yield forestry combined with considerations of community stability and economic development. According to Pecore (1992), this has produced a "successful equilibrium between harvesting and using only what the land can provide, and maximizing the jobs and other economic benefits that flow from a sustained-yield harvest." To monitor the long-term effects of their forest management system, the Menominees rely on a system of continuous forest inventory. They base their management on 14 forest types with individualized silvicultural prescriptions for each. Both even-aged and uneven-aged silvicultural methods are used. The goal is to sustain a natural and diverse mosaic of forest types that are sustained through long-term management policies. "Indians accept these long-term policies because they believe that they do not inherit the resource from their ancestors; rather, they borrow it from their children" (Pecore 1992). After 138 years of timber harvesting, the stocking of sawtimber on the ecologically diverse 220,000-acre forest remains as it was in 1854, at 1.5 billion board feet.

Forests are thus a part of the "commons," which includes not only trees but also the air, water, soil, settings for human spiritual renewal, and other values that society demands from forests. It would accordingly seem natural, especially in a democratic society, to build forestry policy around public opinion and a consequent definition of the sustainable forest. The resulting management, although *socially acceptable*, may not necessarily be *socially desirable*. A forestry based solely on a publicly agreed upon visualization may be no more sustainable than that which the public earlier disagreed with. We therefore need to better understand how socially constructed landscapes evolve. A good place to start is by recognizing that the personal idealization of nature, the human landscape experience, and the dislike of disruption and change are all parts of human culture. It is this culture that inevitably influences and judges forest management practices. Only when sustainable forestry is defined by more than the science and art of forestry can a socially desirable *and* acceptable framework for its application be formulated.

Silviculture is clearly anthropocentric. It provides a framework for constructive human interaction with forests that, by its very definition, endeavors to sustain forests. But a forest is comprised of more than trees. It is an object of societal expectations that are diverse and often divergent. This raises the dilemma of identifying the area of common agreement

among the potentially conflicting disciplines of economics, ecology, and sociology, which themselves are components of forestry. Wilson's (1998) concept of *consilience* provides a basis for dealing with such problems. Consilience, he said, is "a jumping together of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation." Wilson also noted the difficulty in attaining consilience. Barriers to solving interdisciplinary problems abound in the form of disparities among disciplines in terminology, methods of analysis, and scientific philosophies. These issues are all too familiar within forestry, which itself is multifaceted. The concept of forest sustainability clearly involves more than a single discipline. According to Wilson, "true reform will aim at the consilience of science with the social sciences and humanities in scholarship and teaching." Similarly, if the concept of forest sustainability is shaped by only one perspective, we will be accordingly disadvantaged in arriving at effective solutions to the problem. A diamond is but a unique rock until someone cuts it. Until then, its many facets are without fully realized value and beauty. So it is with forest sustainability. Only by breaking through disciplinary boundaries is it likely that the concept of sustainability will realize its full potential as a system of practices and policies that reveals the whole jewel: the sustainable forest.

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Pioneer Forest: A Case Study in Sustainable Forest Management

Greg F. Iffrig, Clinton E. Trammel, and Terry Cunningham[1]

Abstract.—To demonstrate the economic success of single-tree selection forest management, data from one of the longest running and most extensive forest research projects in the Midwest are presented. Tree growth data, along with known market prices during a 45-year period, are used to demonstrate significant economic advantages for private landowners from using single-tree selection over even-aged forest management.

Pioneer Forest was established in the 1950s to demonstrate the long-term benefits of sustainable forest management using a method of uneven-aged silviculture known as single-tree selection. Beginning in 1952, a continuous forest inventory has been conducted on these lands, measuring various components of the forest at 5-year intervals, including species diversity and various tree characteristics—height, diameter, and condition. When combined, such measurements provide a unique view of the dynamics of a forest of nearly 160,000 acres, monitoring change over long periods of time.

Certain measures of species distribution within the forest canopy show little change over this 45-year period. Measures of diameter distribution demonstrate the ability of an uneven-aged forest management system to maintain periodic harvests while carrying higher quality trees through time in order to establish larger diameters, higher quality individual trees, and the inherent structure of a multilayered and multiaged forest.

From our research, other benefits of single-tree selection harvest include a periodic income for the landowner, successful and natural regeneration of forest species, and restoration and maintenance of the forested landscape.

INTRODUCTION

The Ozark Region of Missouri harbors the State's most extensive (Hahn and Spencer 1991) and diverse (Nigh *et al.* 1992) forested land. It is a rugged region with the highest biodiversity anywhere in Missouri. Despite early logging activities, which began as early as 1887 (Cunningham and Hauser 1993), these rugged and forested hills have recovered their richness of species and their productivity. Ozark woodlands produce a variety of high-quality wood products including flooring, cabinets, veneer products, finished lumber, and barrel staves.

The biological relationships here are complex. Despite nearly a century of recovery and decades of research, questions are still being asked and answered about the many ways the Ozark Region and its biological resources, especially the forests, contribute to overall conservation programs (see Robbins *et al.* 1989 and Robinson *et al.* 1995). Wildlife conservation efforts have affected both public and private land and have been successful largely due to regulations governing hunting, fishing, and trapping with seasons; bag limits; individual licenses; and in some cases species-specific

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tags or permits. On the other hand, since trees do not move across land ownerships, our efforts to maintain the forest resource of the Ozarks may not be as successful as previous efforts to conserve wildlife resources in this same region.

Since 83 percent of Missouri's forest land is in private ownership (Spencer *et al.* 1992), major changes in the methods used to harvest forests in the Ozarks could bring far-reaching effects. The eastern Ozarks contain the majority of Missouri's forest resource; and even here, 61 percent of the forests are privately owned (Leatherberry 1990). Recent changes in the wood products industry suggest wholesale change is about to occur in this most important forest region of Missouri.

During the 1990s, the Ozarks witnessed new demands on forest resources from several fronts. Perhaps the greatest future impact may result from high-capacity chip mills both in Missouri (Mill Spring in Wayne County and Scott City in Scott County) and in out-of-State locations whose source areas reach into Missouri (Menifee, Arkansas and Wycliffe, Kentucky). These mills supply other primary pulp and paper mill facilities, all of which are located either in other states or overseas. They have opened new markets for wood products from the Ozarks. The primary impact upon private forest land is that the total resource can be cut more extensively, including trees with very small diameters. Cutting forested land in this manner results in a much longer period of recovery. Furthermore, because recovery in the Ozarks may take 30 to 40 years just to produce diameters acceptable even for use as pulp products, private forest land harvested in this way may be permanently shifted into producing these lowest value wood products. This effect would substantially degrade the forest resource, affect its quality for wildlife, and subject future landowners to either a reduced income or the choice of converting a forest to non-forest uses. This decline in the Missouri Ozark forests of the next century would ultimately affect all Missourians in ways similar to those that resulted from the forest devastation of 100 years ago, as described by Cunningham and Hauser (1993).

The ability to remove more of the wood product and to remove it more efficiently is demonstrated by recent chip mill activity but also by overall change in the industry including larger and more mechanized saws, delimbers, grapple skidders, and other equipment and has already created new logging opportunities on relatively inexpensive Ozark land. In the heart of the Ozarks, numerous large clearcuts already exist as examples of these extensive logging practices.

While new to the Missouri Ozarks, these same pressures have already impacted many other states. Without an alternative strategy for the private landowner, the future condition of our Ozark forests would match the impacts already evident in many Southeastern States, including Alabama, North Carolina, Mississippi, Georgia, Kentucky, Tennessee, and to an increasing extent, our neighboring State of Arkansas. Private forests in the Ozarks demand a readily available management alternative that does not remove the forest but that treats every acre of the forest as a permanent resource—thus providing immediate as well as periodic future returns to the landowner.

In this case study from Pioneer Forest, we present another point of view for private forest management. Since the 1970s, the literature has been replete with suggestions for even-aged (clearcutting) management of Ozark forests (Sander *et al.* 1984, and others). For an especially accurate overview, see Johnson 1992, particularly the section "The History and Application of Clearcutting in Ozark Forests." Results from Pioneer Forest, the longest running and most extensive forest research project in Missouri, show that uneven-aged forest management is highly successful and substantially more profitable than even-aged management. Throughout the United States uneven-aged forest management has been successfully practiced in several forest types commonly thought to require even-aged management techniques (Farrar 1996, O'Hara 1998, Guldin and Baker 1998, Seymour and Kenefic 1998). This paper presents the results of a 45-year study on a privately owned oak, hickory, and pine forest in the Missouri Ozarks. A particular style of uneven-aged management, best described as single-tree selection harvest, was adapted for use here beginning in the early 1950s. Data indicate that this technique has been and should continue to be successful in the management of Ozark forests. It is easy to apply, produces regular income, successfully and naturally regenerates Ozark forest species, and

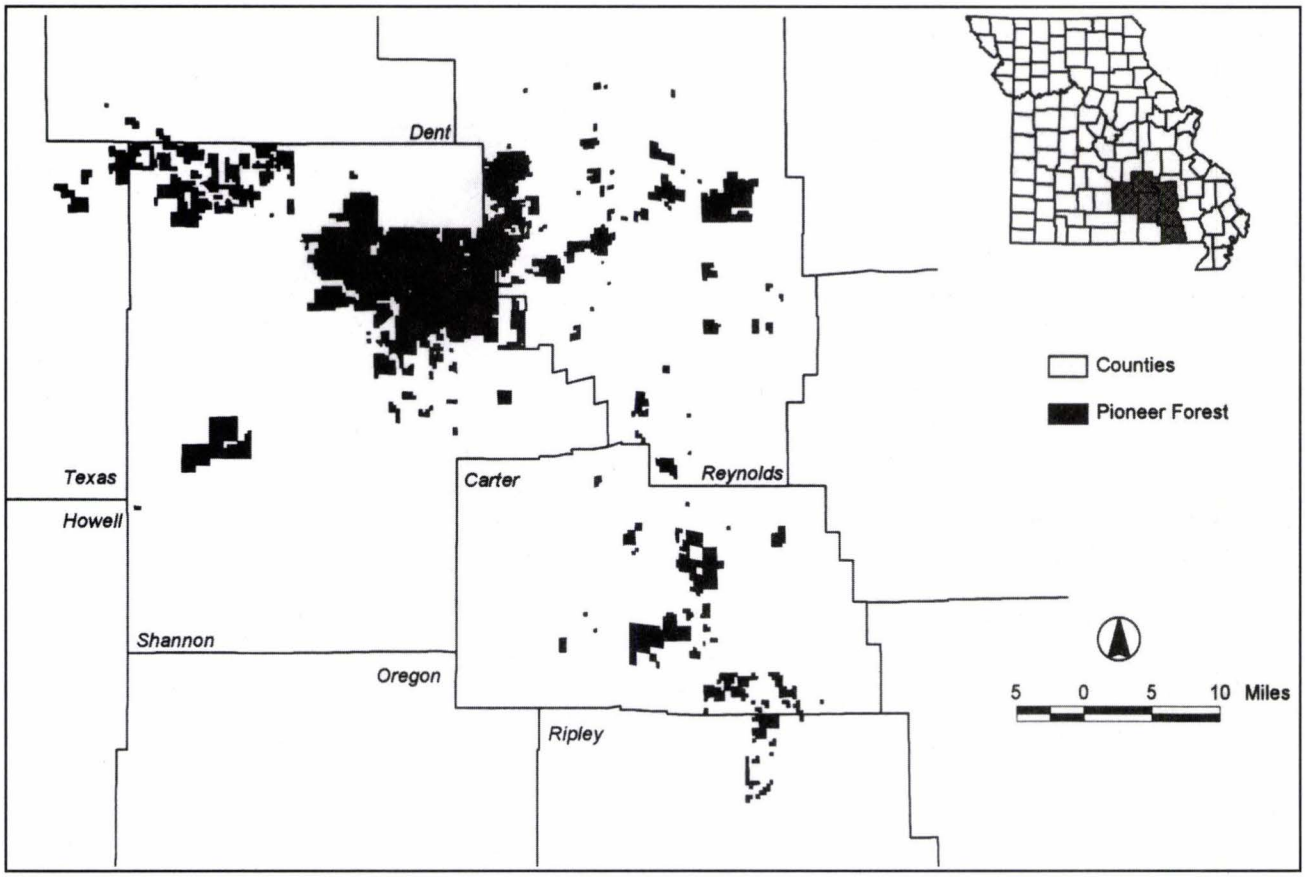


Figure 9.1—*Pioneer Forest.*

not only maintains but also improves the overall health of a forested landscape.

STUDY AREA

Pioneer Forest is a large, privately owned forest of nearly 160,000 acres (see fig. 9.1). These forest lands are part of the oak, hickory, and pine forests in the Missouri portion of the Ozark Highlands. The Ozark Highlands is part of the most extensive elevated landscape between the Appalachian Mountains to the east and the Rocky Mountains to the west. It is the Salem Plateau of the Ozark Highlands on which most of Pioneer Forest is located. The topography is largely erosional with the greatest variation in elevation (generally 700 feet or less) occurring along the major rivers. Bedrock here is dominated by the more soluble dolomites, limestones, and sandstones and as a result includes many classic karst features. Situated in an area of spectacular springs, clear rivers, towering bluffs, losing streams (Vineyard 1974), and numerous caves, these lands include significant portions of the spring-fed watersheds of the Jacks Fork and Current Rivers.

A major part of the forest lies directly adjacent to Missouri's largest national park, the Ozark National Scenic Riverways; other portions of the forest border the Mark Twain National Forest, as well as State forests and State-owned conservation areas managed by the Missouri Department of Conservation. Total acreage of the forest is more extensive than the lands of the Ozark National Scenic Riverways (estimated at 75,000 acres) and comparable to the total acreage of Missouri's State Park System (estimated at 125,000 acres).

Beginning in the early 1950s, St. Louis businessman Leo Drey began to acquire lands in the Ozarks in an effort to demonstrate that taking better care of forests would produce lasting and economically beneficial results for the landowner as well as the neighboring communities. When National Distillers, a private company with lands located in the Ozarks, decided to liquidate its holdings in 1954, it sold approximately 90,000 acres to Drey, who continued to purchase other forest land in the Ozarks for Pioneer Forest. By 1962, he had acquired 134,000 acres.

METHODS

The Design and Description of Single-Tree Selection Forest Management

Single-tree selection management is one of several reproduction cutting methods collectively termed uneven-aged silviculture. Using this conservative silvicultural technique, both managers and landowners are able to continuously maintain a diverse and multiaged forest (a forest with three or more age classes, see figure 9.2) on the landscape while also continuously deriving income from periodic harvests. This forest management technique provides a dynamic opportunity for the forest development and succession that is essential for the continuity of the forest. The single-tree selection harvest technique is the process by which individual trees are removed by cutting. This technique, perhaps more than any other type of uneven-aged management, most closely mimics the natural process that occurs when a single tree or small group of trees in the forest dies. Such small-scale disturbances as lightning strikes or insect attacks are the most common type of disturbance affecting late-successional forest. Single-tree selection has been the only forest management technique practiced on Pioneer Forest since the 1950s.

Our harvests generally occur when a particular stand achieves a closed canopy, visible signs of growth have slowed, and individual trees within both the overstory and understory show stress or old age through evidence of crowding, dieback, or disease. This results in harvest intervals averaging 20 to 25 years. We should note that when uneven-aged management is applied to forests in other regions of the United States, the harvest interval may be longer (for example, in areas west of the Ozarks) or shorter (for example, in states east and south of Missouri), depending on a particular site's productivity. Harvests on Pioneer Forest remove approximately 40 percent of an area's standing volume. The forestwide average standing volume per acre from our 1997 remeasurement was 3,212 board feet per acre (based on the International 1/4-inch scale). The result of single-tree selection harvests is that as many or more trees of all sizes and age classes are left standing as are cut. Even immediately after cutting, every acre remains forested.

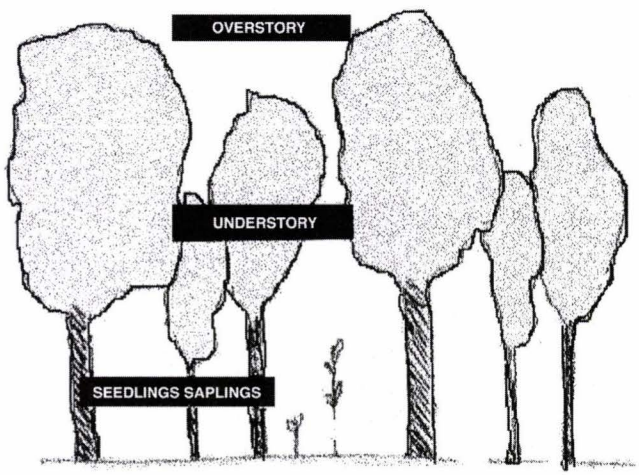
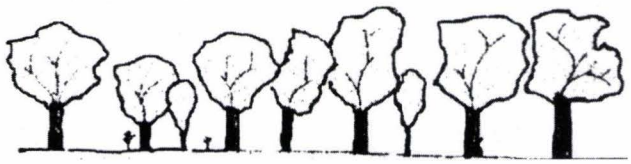


Figure 9.2—*Multiple layers of the forest (typically two or more age classes in the overstory, an understory layer, and the saplings and seedlings growing from the forest floor) as a result of single-tree selection management techniques and characteristic of the forested landscape of Pioneer Forest.*

Commercial contracts are generally made directly with mills and include all marked trees within a given area. The operational unit for a logging contract is a legally described section of land, although marking is completed using an area's topography. Marking, cutting, and skidding begin at the bottom of a hillside and proceed to the top, resulting in the least damage to the trees left uncut (the "leave trees"). Shortleaf pine is marked for cutting beginning with diameters greater than 9 inches at breast height (d.b.h.) and is scaled in 2-foot increments to a 6-inch upper stem diameter. Hardwoods are marked from diameters greater than 10 inches d.b.h. and are scaled in 2-foot increments to a 10-inch upper diameter.

Marking crews examine every tree on every acre of a scheduled harvest to determine which trees will be cut. This is done because the leave trees, those that will remain in the forest, are just as important as those trees which are cut using our conservative single-tree selection technique. The process of choosing trees involves several important and easy-to-apply principles. The instructions of Guldin and Baker (1998) for marking crews in southern pine forests hold just as true for Missouri Ozark forests: the simple concept is "that marking crews cut the worst trees and leave the best within each diameter or product class and among classes if necessary." Figure 9.3 illustrates a step-by-step process for

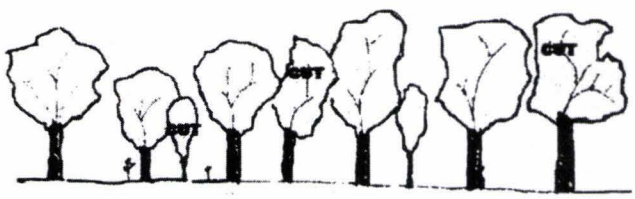
single-tree selection harvests, which includes the principal features of the forest, both before and after the cut, as well as simple parameters that guide marking crews.



CHARACTERISTICS OF THE FORESTED LANDSCAPE OF PIONEER FOREST

Each acre of the forest averages 32.1 trees per acre greater than 11 inches in diameter. Of these, there are:

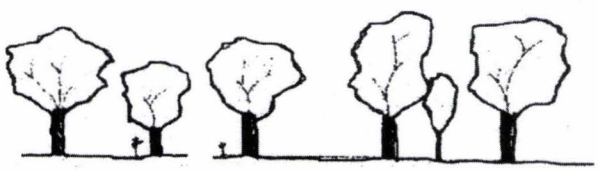
2.6 trees measuring 17 to 22+ inches
11.4 trees measuring 13 to 16 inches
39.4 trees measuring 9 to 12 inches
102.6 trees measuring 5 to 8 inches



HARVESTS ON PIONEER FOREST REMOVE AN AVERAGE OF 12 TO 15 TREES PER ACRE

Harvest decisions on which trees to cut or leave are based on:

Species	Disease/Insects	Position
Age	Wind Damage	Spacing
Vigor	Growth Character	



CHARACTERISTIC FORESTED LANDSCAPE FOLLOWING A HARVEST USING SINGLE-TREE SELECTION TECHNIQUES

- Commercial production provides income
- Canopy gaps are created in the forest canopy
- Light penetrates to the forest floor
- Fully functioning forest remains on the landscape
- Harvest cycle is sustainable

Figure 9.3—*Diagram of the single-tree selection harvest technique using forestwide averages from the 45-year dataset from Pioneer Forest, following the 1997 measurement of the continuous forest inventory.*

As a first step, marking crews within a harvest area work from specific trees that are to be left. Leave trees are the healthiest trees on a site, expressing the greatest potential for growth, but they also are species that are best suited to a particular site. For example, a healthy shortleaf pine growing on a south- or west-facing slope or a white oak tree growing on a north- or east-facing slope would be ideal candidates for leave trees. The tree marker is constantly monitoring individual tree quality, species, and site conditions while moving through an area and across a variety of landscape conditions. The overall objective for a marker is to match the growing stock to the site, giving the leave trees room to grow by removing the poorer quality trees around them. Even poorer quality trees, that would otherwise be cut may be left on site to meet a particular objective. (For example, post oaks are often left for wildlife as mast-producing trees; post oaks and other trees are often left for den trees).

Generally, harvests on Pioneer Forest remove an average of 12 to 15 trees per acre. Individual trees may be marked for cutting based upon the same factors, which change depending upon the slope, aspect, physical condition of a tree, and past history of the area. For individual trees, variables to consider include age, tree species, tree quality, presence of trees affected by disease, pests, deformities or damage, and the general spacing of the trees as evidenced on the ground but, often more importantly, observed in the forest canopy.

Cutting a marked tree leaves an opening in the canopy. This opening provides an opportunity for the best trees to continue their growth. Leave trees benefit from the small gap that adds light and reduces competition for space, water, and soil nutrients. Seedlings germinate and other saplings and understory trees grow into this newly created space in the forest benefiting other trees in the forest that have not grown into the canopy, and the seedlings on the forest floor develop into saplings. This progressive development of small trees into large ones and the simultaneous occurrence of all diameters within the forest are critical to the method's success.

It is common to be standing in the forest and, while choosing the best trees to be left, notice a stump nearby that was created from the

previous cut, and older stumps as well, particularly pine that may have been cut 40 or more years ago, and see younger trees growing into that space. We often notice trees left that were poorer trees but that had remained for a reason. These qualitative examples, encountered on a daily basis, demonstrate the continuous succession occurring within the forest and exemplify the importance of these small gaps in the canopy in helping to produce the highest quality canopy trees while also regenerating oak and hickory seedlings on the forest floor in the Ozarks.

Continuous Forest Inventory

The method of establishing a long-term data set for Pioneer Forest was derived in part from the work of the Ford Forestry Center in L'Anse, Michigan, through the establishment of permanent sampling plots designed to measure growth of northern hardwoods following selection cutting. For a discussion of this system, see Stott (1966) and Meteer (1966). The technique is to measure change and growth through comparable measurements on the same trees in the same plots, in order to be representative of the forest as a whole and its various overstory and understory components (Meteer 1966). This technique was chosen to provide a representative sample large enough to accurately answer questions regarding any part of the forest. Particularly for long-term projects, this method makes it possible to compare growth figures as well as the developments and changes occurring within the forest.

Once installed, these permanent plots are subject to the same kind and intensity of treatment as applied to the forest surrounding them. Doing so ensures that data from the plots reflect the overall management of the forest.

Permanent research plots, one for each 640 acres of the forest, were established in 1952 to initiate the continuous forest inventory. Each plot measures 0.2 acre. Following this first measurement, one additional plot for each 640 acres was established and the first measurement of the total number of plots began in 1957. Initial information was collected from all trees 5 inches d.b.h. or greater within each permanent plot. Each tree measured was also numbered and the species recorded, along with the merchantable height to the nearest 2-foot class, percent soundness, and tree condition. Today, there are 486 0.2-acre permanent plots, which are remeasured every 5 years. This intensive effort provides a continuously updated data set on the dynamics of growth and development for understory and canopy trees within a forest managed by the single-tree selection harvest technique.

RESULTS

The results we present are based on the cumulative data for the period of 1957-1997. During this entire period, the forest (including the permanent plots) was commercially harvested an average of every 20 to 25 years. With harvests ongoing throughout the forest, volume per acre measurements show how forest restoration has been achieved through adoption of the single-tree selection management technique (table 9.1). The forestwide average volume per acre has increased by 184 percent since 1952.

Table 9.1—*Volume (board feet, International 1/4-inch rule) of merchantable saw log trees per acre by seven species groups, Pioneer Forest (hardwood trees > 10 inches in diameter and shortleaf pine > 8 inches in diameter)*

Species	Year								
	1957	1962	1967	1972	1977	1982	1987	1992	1997
Red Oak	575.5	695.2	802.9	842.2	792.1	812.1	813.4	963.8	1,211.4
Shortleaf pine	111.1	188.3	240.4	396.4	546.2	648.1	736.7	878.6	1,081.6
White oak	192.6	233.8	269.9	291.0	293.1	339.9	407.7	496.3	653.6
Hickory	78.6	79.6	89.3	98.9	96.0	95.7	99.3	110.5	110.9
Post oak	55.8	63.9	70.2	60.2	53.5	48.5	47.7	52.3	60.5
Blackgum	66.4	64.1	64.2	53.9	39.1	24.0	18.2	9.4	9.1
Other species	156.0	84.1	58.1	54.4	35.0	55.6	76.1	77.1	84.9
TOTAL	1,236	1,409	1,595	1,797	1,855	2,024	2,199	2,588	3,212

In addition to the total, it is significant to note how the increases are accounted for by species. The results presented in table 9.1 are for seven species or major groups of species represented on the forest. These are red oak (including black oak, scarlet oak, northern red oak, shortleaf pine, white oak, hickory, post oak, blackgum, and all other species as a separate group. Except for blackgum, the species or species groups have maintained their relative proportion of the forest mix. Shortleaf pine shows a marked increase from the initial pine measurement in 1957 to 1997, relative to both red oak and white oak. While white oak increased slowly after 1957, the species more than doubled in volume per acre in the past 20 years. The "other species" group has remained relatively unchanged since 1962. "Other species" includes sugar maple, a shade tolerant species, traditionally thought to threaten canopy dominance in Ozark forests (Nigh *et al.* 1985, Pallardy 1991).

Equally significant, especially from the standpoint of maintaining the characteristic layering of large and small diameters within a forest, is the change in distribution of diameters on this uneven-aged forest through time (table 9.2). Except for the larger diameter classes (those exceeding 18 inches), each diameter class has either increased or maintained itself. The larger diameter classes have not increased, but rather have fluctuated around the initial measurement figure.

IMPLICATIONS FOR MANAGEMENT

We have presented a summary of the science of applying uneven-aged management principles to an Ozark forest over an extended period of time. These summary results indicate that for the 45-year period, the practice has been highly successful. In fact, the results of this study extend beyond the time period during which the practice of even-aged management (clearcutting) has been practiced in Ozark forests (Johnson 1992). The basis for measuring success for the private landowner, however, lies in establishing a sustained and significant economic return as well as improving the quality within the forest. We can now use these species growth data along with known market trends during this period to compare actual economic returns from using uneven-aged management with the alternative of even-aged management (clearcutting).

The Economic Advantages of Uneven-aged Forest Management

At least one other Missouri study compared the economics of uneven-aged management over even-aged forest management techniques. Trammel (1991) evaluated various management practices and their economic return to the landowner from Ozark forest lands other than Pioneer Forest. Using a constant market price for the sale of oak-hickory saw logs through an 80-year time period, Trammel found

Table 9.2—*Basal area per acre by diameter (inches at breast height) class for Pioneer Forest*

	Year							
	1957	1967	1972	1977	1982	1987	1992	1997
Diameter (inches)								
6	6.69	8.50	8.71	9.40	9.38	9.14	10.3	10.75
8	6.27	7.95	8.43	9.51	10.71	11.35	11.62	12.34
10	6.13	7.93	8.93	9.28	9.84	10.89	11.67	12.84
12	5.39	7.05	7.22	8.00	8.60	9.07	9.68	11.53
14	4.42	5.81	5.04	5.39	5.79	6.19	6.72	8.43
16	2.29	3.71	3.25	3.17	3.43	3.20	3.60	4.97
18	1.13	1.84	1.70	1.27	1.47	1.70	1.85	2.83
20	0.55	0.85	0.89	0.85	0.70	0.63	0.93	0.58
22	0.13	0.32	0.45	0.47	0.45	0.34	0.44	0.18
24+	0.38	0.35	0.06	0.16	0.16	0.28	0.39	0.35

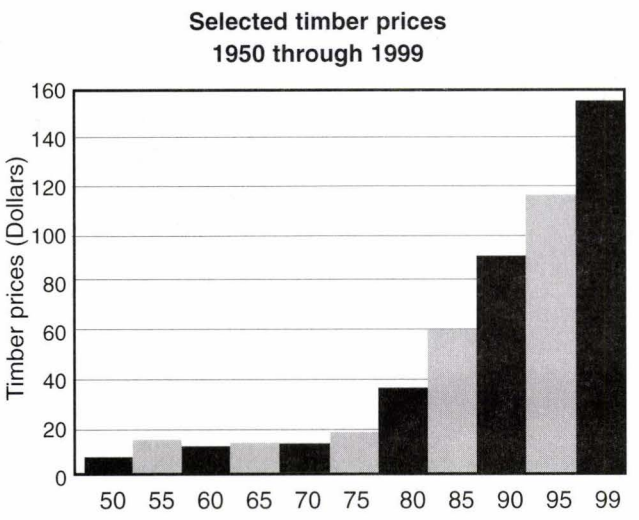


Figure 9.4—*Selected prices[2] (per 1,000 board feet) for standing trees sold from Pioneer Forest during the period 1950-1999.*

comparatively equal returns for both even-aged management and uneven-aged management. However, any landowner is subject to market conditions at the time of each sale. The biggest single difference here is that landowners who choose to sell all of a timber resource during one market period do not benefit from the advantages of changing market conditions, particularly the real changes which have occurred for actual timber markets in the Ozarks.

Uneven-aged management uses periodic harvests to produce income and protect forest assets for their long-term value. This periodic harvesting is much like periodic investing in the sense that a private landowner (or a public agency) can use changing timber markets to produce higher long-term economic returns with this more conservative forest management technique. Figure 9.4 shows specific market prices from timber sales on Pioneer Forest since 1950. Market prices are listed in terms of 1,000 board feet of merchantable saw logs. This is the traditional scale used by loggers, sawmills, landowners, and the public agencies in establishing industry prices for selling standing trees. Observers in the industry know that specific prices at any given time may vary depending upon who is selling or scaling marked trees. To remain consistent, we have used the prices established in a given year by Pioneer Forest for its merchantable saw logs during this period. We would expect that any comparison of similar land during this same period would indicate the same trends, if not the same prices, for any particular year. During the first 25-year period, prices tripled ($6.00 to $18.46), but even more interesting is that during the most recent 25-year period, the price for standing trees again increased—by 745 percent (from $18.46 to $156.00). This total increase seems high; however, when the total increase in sales price for the past 24 years is calculated as an annual compound interest rate, it is 9.3 percent per year. Research from other states and nationwide figures are similar (see Clash 2001).

With year-to-year changes in the Consumer Price Index averaging 3.4 percent (based on the period 1914-1996; distribution data from Ohio State University; www.hec.ohiostate.edu/hanna/ext/cpidist.htm), even when adjusted for inflation, annual returns from Ozark forest lands managed in this manner exceed 5 percent. When compared with other investment opportunities, conservatively managed forest land proves to be a rewarding investment. Clearly, private landowners and forestry consultants should be interested in this approach as an alternative to even-aged management strategies even though, like the stock market itself, no one can predict the future. But if the past 50 years is any indication, good quality standing trees in Ozark forests are becoming more valuable and at an ever-increasing rate.

A Specific Example of the Income Opportunities from Managing Ozark Forest Land During 1975-1999

Using known annual growth rates from this study and actual market prices from figure 9.4, we can now apply these factors to an acre of Ozark forest land managed using both even-aged techniques and uneven-aged techniques and derive the economic benefit to a landowner. In 1975, if we applied even-aged management to an acre of land having 3,000 board feet of merchantable volume and clearcut that land, selling all merchantable

[2]Records of National Distillers 1950-1953; records of Pioneer Forest 1954-present. As a comparison to our 1999 prices, published records from Missouri Price Trends (Missouri Department of Conservation, October-December 1998) indicate that the weighted average from reported sales for the Ozark Region was $145 for mixed hardwoods and $160 for mixed species of oak.

trees at the indicated market prices at that time, the landowner would have netted $55.38 (see table 9.3).

Then, if that money were invested at 5 percent compounded annual interest for 24 years, the current market value of the return from that acre of land would be $178.61. Additionally, the private landowner would have the value of the clearcut forest land with 24 years of growth, although actual value of the forest product increment here would be negligible (even after 24 years of growth, a 24-year-old clearcut does not have any saw log-size trees).

If that same acre of Ozark forest land had been managed using uneven-aged techniques, the acre would have been only partially harvested in 1975, removing 40 percent of the volume. Management costs, or the fees a landowner might pay to a consulting forester or professional forester to mark the individual trees to be cut, are estimated at 5 percent in 1975 terms. Therefore, the net return from the harvest, with management costs deducted, would have brought the landowner $21.04.

Table 9.3—*Calculating the net return from an average acre of Ozark forest land managed since 1975 using an even-aged technique versus the single-tree selection technique*

General formula for calculating return from harvest:

$$\frac{\text{Volume}}{1{,}000} \times \text{Price Per } 1{,}000 \text{ Bd Ft} = \text{Return}$$

Single return from even-aged harvest: Calculation of the return from even-aged management on an acre of Ozark forest land in 1975:

$$\frac{3{,}000 \text{ Bd Ft}}{1{,}000} \times \$18.46 = \$55.38$$

Initial return from single-tree selection harvest: Calculation of the initial return from uneven-aged management of an acre of Ozark forest land in 1975.

$$\frac{1{,}200 \text{ Bd Ft}}{1{,}000} \times \$18.46 = \$22.15 - \text{Mgmt cost} = \$21.04$$

Second return from single-tree selection harvest: Calculation of the return from the second harvest (1999) of an acre of Ozark forest land using uneven-aged management.

$$\frac{1{,}680 \text{ Bd Ft}}{1{,}000} \times \$156 = \$262.08 - \text{Mgmt cost} = \$235.87$$

Then, if this return had been invested as above (5 percent interest, compounded annually), the value today would be $67.86. Additionally, if the remaining forest had grown at conservative rates of 100 board feet per year (actual averages from this study show an increase of 124.8 board feet per acre per year since 1992), then the acre of uneven-aged forest would have contained 4,200 board feet by 1999. Again, in 1999, we would conduct another partial harvest, selling at current market rates of $156.00, bringing $262.08 from the acre. Deducting an average consultant/management fee of 10 percent (suggested management fee for the current year), the landowner would net $235.87.

Combining the amount invested since 1975 (and now worth $67.86) along with current net proceeds ($235.87) from a second single-tree selection harvest, the total amount obtained by the private landowner is $303.73. So using the uneven-aged management technique, when compared to even-aged management, returned nearly double ($303.73 versus $178.61) to the landowner following just two harvests. Remembering that once an acre of forest is cleared, it will require a period of at least 80 to 100 years to regrow and during this same period of time uneven-aged management is applied four times. Also during this 80- to 100-year period, even-aged management would also require a non-commercial thinning at an added cost and which we have found to be unnecessary using uneven-aged management techniques.

Uneven-aged forest management allows public or private landowners to capitalize on changing market conditions and capture increasing values of forest products. This technique of managing a forest is also more compatible with a private landowner's individual planning horizon. It is highly unlikely that any current forest landowner will be able to wait the 80 to 100 or more years to regrow their trees after clearcutting. For any landowner, public or private, uneven-aged forest management returns many other values that we have not counted in table 9.3 including the standing value of the uncut forest, the benefit of periodic income, a variety of recreational values such as hunting, or the continuous aesthetic enjoyment of a forest. Following this example of uneven-aged management, many tracts on Pioneer Forest have been harvested three times since this study began in 1952.

Maximum Sustainable Volume

One measure of the forest that is of particular interest from an economic viewpoint is the potential of any given acre of the forest to produce or hold a maximum sustainable volume. We can see from the data presented here that, at least for Ozark forests managed by uneven-aged techniques, we still have not realized what the potential average yield per acre will be. Based on our data, the standing volume per acre of merchantable saw logs has continued to increase following each measurement period from 1,236 board feet/acre in 1957 to 3,212 board feet/acre in 1997. This means that we still have not realized the maximum potential for harvest using uneven-aged management techniques—that is, we have not reached the full carrying capacity of the forest. For example, we would expect at some point to see the increase in standing volume to change, either to begin to level off, or possibly to decline and then level off. Once that happens we will have an indication of what the maximum sustainable volume, or carrying capacity, of the forest will be for this portion of the Ozarks.

CONCLUSIONS

We have described a part of the potential economic benefit to a landowner who chooses to use single-tree selection as a forest management tool. Additional values remain within the forest itself. Using single-tree selection leaves a productive and healthy forest in place year after year. Remembering Guldin and Baker's simple guideline of cutting the worst and leaving the best, a managed forest can continue to return ever greater economic and social benefits in the future. The extensive data collected thus far offer the following measures of the improved quality of an Ozark forest managed with uneven-aged techniques:

- Volume per acre of the forest continues to increase as the forest continues to grow.
- The forest is continuing to perpetuate itself. During the 45-year period of the study, seedlings and saplings have continued to grow, advancing into the measured diameter classes; in fact, basal area measurements for individual trees below 16 inches d.b.h. have nearly doubled for every diameter since 1957.
- Species volume in saw logs per acre has increased in all species groups except for post oak and blackgum. At least for the dominant species, the changes are positive.
- These same results can be easily duplicated for similar forested areas throughout the Ozarks. Applications of uneven-aged management can be very consistent. Data from the 40-year period (1952-1992) have been examined by Loewenstein (1996). Using a chi-square test, diameter distributions from these plot data conform to forestwide averages at a scale of 0.6 acres.
- Shade-tolerant species, such as sugar maple, have not become a problem; in fact, the measure of their presence has remained relatively constant over more than 40 years.

SUGGESTIONS FOR FURTHER STUDY

The report and analysis of these results point to several areas worthy of further research. The results clearly indicate a regenerating forest, although additional data specific to seedlings/saplings are needed. Beginning in 1992 we improved our research efforts in two ways. With initial help from the University of Missouri and the USDA Forest Service, North Central Research Station, we began to collect additional data from the permanent plots on all individual trees between 1.5 and 5.0 inches d.b.h. In 1992, we began to collect more specific regeneration information, including woody species from the groundcover up to 1.5 inches d.b.h. These studies will provide an indication of the more specific dynamics operating within this management system, one that continually grows individual trees of all age classes necessary to sustain the forest.

Also needed is an examination of the entire species distribution within the forest. At least for remeasurements beginning in 1962, that information is available although not reported here. For blackgum, a characteristic species of the Ozark forest, our data indicate a significant reduction in its presence on the forest. The grouping of "other species" from table 9.1 also shows a decline during the late 1970s and early 1980s. Since then, that overall number shows an increase. Further analysis of this forest species diversity over time would be helpful.

ACKNOWLEDGMENTS

The magnitude of this study would not have been possible without the initial interest of National Distillers under the leadership of Ed

Woods. National Distillers began to establish the first permanent plots in 1952. The first remeasurement in 1957 included National Distillers' lands that Leo Drey had purchased in 1954, along with other properties Leo had already purchased and together named Pioneer Forest. At that point, Leo Drey made a long-term commitment not only to single-tree selection harvest as the only management on the forest but also to the ongoing collection of data in the same manner begun by National Distillers. Since 1952, there have been a number of staff members involved in the collection of data on Pioneer Forest. The first staff of Pioneer Forest included Ed Woods along with Charlie Kirk, Lee Paulsell, Paul Corder, Rayburn Skaggs, and Russ Noah. Other staff involved during the data-collection efforts have been Steve Lindsey, Keith Jones, Steve Wells, Steve Whitaker, Dan Skaggs, Mike Adams, Tim Dyer, and the authors. Periodically, other individuals also have assisted the staff including Dave Larsen, Mike Higginbotham, Hank Dorst, and Scott Larsen. We also gratefully acknowledge the review comments of Paul Gagnon, James M. Guldin, Alan Journet, and Bill Kurtz on earlier drafts of this paper.

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Trends in Demands for Missouri Forest Lands

William B. Kurtz[1]

Individual, private forest landowners are quite frequently at odds with society over the demands placed on private forest lands. This discussion is an attempt to put this disagreement into perspective for Missouri forest lands.

SOCIETY AND INDIVIDUAL OWNER DEMANDS

Society places a multitude of demands on our forests, both public and private, as numerous studies have found, and these demands can be in sharp contrast with those demands that individual private owners place on their forests (table 10.1). These demands can be categorized as consumptive or non-consumptive of the forest resource (Sorg and Loomis 1984). Note further that society's demands are of a much longer term nature than individual owners' demands. In addition, it is obvious that society's demands are of a more aggregate nature, able to be captured by the public at large, while the individual owners' demands are generally captured in a more exclusionary, individual sense.

Table 10.1 — *Society and private owner demands placed on forests*

Society (long-term)	Individual owners (short-term)
Air cleaner	Income
Biodiversity sanctuary	- Periodic
Carbon sequestration	- Savings account
Endangered species haven	Firewood
Erosion arrestor	Management skill
Fiber producer	Pride
Recreation provider	Recreation site
Soil conditioner	Release
Tax contributor	Residence / Space
Visual enhancer / Natural beauty	Solitude / Contemplation
Water filter	Spiritual
Water storage	Wildlife
Wildlife habitat	- Hunting
	- Viewing

FOREST AMENITY VALUES

Forests provide many values other than timber, and sometimes these values are very difficult to estimate (table 10.2). Sorg and Loomis (1984) compiled a group of estimates of what would be called amenity values, non-consumptive values for forests. The value is estimated based on net willingness to pay over and above expenditures—how much more you would pay to have that particular experience over and above what you are actually spending for that experience. All values are in terms of an activity day, which is the amount of time in a day devoted to the primary activity.

The values vary widely from less than $10 to over $130 per activity day. Since the study reviewed literature from a wide period of time, inflation was taken into account when these estimates were made. The main point is that people place a monetary value on these activities and are willing to pay to participate.

One of the important processes that we neglect to account for and that is impacting us

Table 10.2 — *Estimates of forest amenity values*

Forest use	Value[1] range estimate per activity day[2]
Anadromous fishing	$25 - 99
Big game hunting	$18 - 131
Camping	$ 5 - 26
Downhill skiing	30
Cold water fishing	$ 9 - 67
Hiking	$ 8 - 45
Picnicking	$ 6 - 28
Small game hunting	$15 - 45
Wilderness	$12 - 73

Source: Sorg and Loomis 1984.

[1] Value is the net willingness to pay above expenditures.
[2] Activity day is the amount of time in a day that is devoted to the primary activity.

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today in Missouri, as well as in other states is population growth in rural areas and attendant fragmentation of forest lands. In 1978, there were 80,700 private forest ownerships in Missouri; by 1994, this number had increased to 307,200, nearly half of whom owned fewer than 10 acres (Birch 1996). As an example, in the heavily forested, 10-county South Central Missouri Region identified by the University of Missouri Office of Social and Economic Data Analysis (OSEDA), population growth between 1990 and 1998 was approximately 31,000 persons, an 11.7 percent increase. The unincorporated area absorbed the bulk of the growth (18,000), while the incorporated areas took in only 12,000 persons. This means that people in this area are carving out home sites in the forests. Many people want to live in the forests—we saw the reasons earlier. This is something that must be taken into consideration, since residential growth is a major demand on forests and on forest lands. Not only does that type of demand utilize forest land in a nonrenewable fashion, most of these people have septic tanks that impact water quality. Frequently, water quality issues are overshadowed by something we can easily see, the disappearance of the forests. Further, such development on a region-wide basis has resulted in significant fragmentation of our landscape: inconsistent and disjointed patterns of use that perhaps will result in long-term adverse consequences for numerous species, as well as other unforeseen consequences.

PRIVATE FOREST OWNER BEHAVIOR

We understand the idea of owner behavior. Over the last 50 years, there have been many studies on non-industrial private forest (NIPF) owner behavior, too many to attempt to chronicle. NIPF owners are a very diverse lot, and most of them are a bit older than other types of owners. Landowner intentions vary widely and they vary with time; many are absentee owners. Lewis (1979) and Trokey (1981) both found significant proportions of absentee Ozark NIPF owners residing in St. Louis and Kansas City. Likewise, in a Wisconsin NIPF study, in the northern part of the state, a good number of owners resided in Chicago and Milwaukee (Marty *et al.* 1988). Another aspect that causes some concern is the high turnover rate of owners. In the past, a number of studies showed that the turnover average for NIPF owners was from 17 to 20 years (Turner *et al.* 1977). However, a more recent study by Birch (1996) estimated mean period of forest land ownership to be 28 years in Missouri. Also, timber production may not be the primary goal of those owners, although in some instances it is.

In 1989, approximately 85 percent of the forest land in Missouri was owned by private landowners: 37.6 percent by farmers, 6.9 percent by miscellaneous corporations, and 38.8 percent by private individuals (Hahn and Spencer 1991). Nationwide, NIPF owners control 58 percent of forest land (Birch 1996). Birch (1996) described the ownership characteristics of private forest landowners in the Northern states. In summary, 72 percent of those responding owned less than 10 acres and 86 percent owned less than 50 acres. In Missouri, some harvest experience was reported by less than 42 percent of owners, and 28 percent plan to never harvest. The greatest proportion of land was held as part of a farm, and the smallest proportion was held for timber (see fig. 10.1).

Most NIPF owners do not manage their lands or do not manage them in a wise manner. Birch (1996) documented that 88 percent of the ownerships representing 66 percent of the forest acreage had no written plan. Several studies were conducted in the Missouri Ozarks to discover how to encourage NIPF owners to better manage their resource from the perspective of stewardship (Lewis 1979, Kurtz

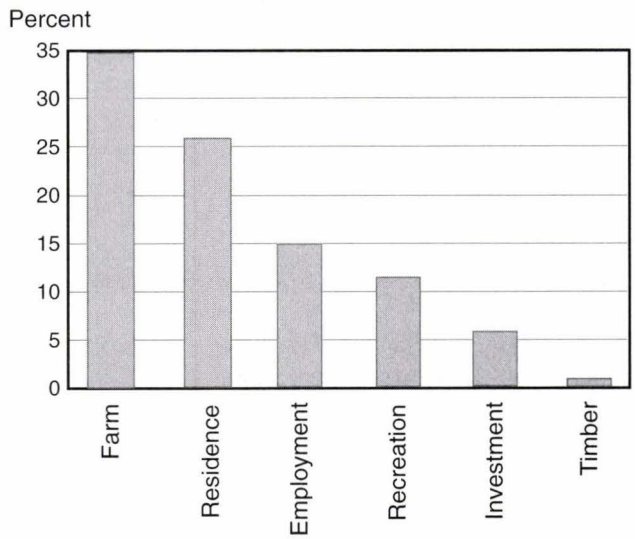

Figure 10.1 — *Proportions of NIPF ownerships, by ownership objectives, in the northern United States (Birch 1996).*

and Bradway 1981). Four types of NIPF owners were identified and described.

a) **Timber agriculturalist**—Members of this group are timber production- and business-oriented. They feel that timber should be managed like a crop in a sustained fashion. Responsible timber management is considered to provide other amenities; wildlife is very important to this particular group because they get satisfaction from its presence. While the smallest group in terms of numbers, timber agriculturalists control the greatest proportion of forest land (fig. 10.2).

b) **Timber conservationist**—A longer term perspective with respect to the resource held by this group. Timber management is considered to be important, but the resource has to be protected for future generations and management should be beneficial to wildlife and other amenities. Members have a strong social perspective and are concerned about resource stewardship. They have a feeling for both production on one side and resource conservation on the other, and they are very concerned about the conversion of forests to grazing. This group includes 26 percent of the owners with 19 percent of the land (fig. 10.2).

c) **Forest environmentalist**—The third group is comprised of members who have a strong feeling for the environment, are close to the land, and are interested in the enjoyment of environmental and other amenities. One owner said, "I own 640 acres and I wouldn't put a saw in it. It's my nature preserve and I'm going to leave it like it is." They feel the forest is a reservoir of benefits, beauty, privacy, wildlife, spirituality, all of these things. Timber management is acceptable, if it does not destroy the beauty of the forest. The visual amenity is very important, yet at the same time, members recognize the investment value of the forest. One-third of the owners are in this group and they own 24 percent of the land (fig. 10.2).

d) **Range pragmatist**—This group holds a distinct business and production orientation, a short-term orientation. Members' woods are used to graze cattle; one person was even grazing hogs. Timber harvest is important only if it is profitable, and range pragmatists are the least likely to manage the forest. This group contains 24 percent of the owners, who own 12 percent of the land (fig. 10.2).

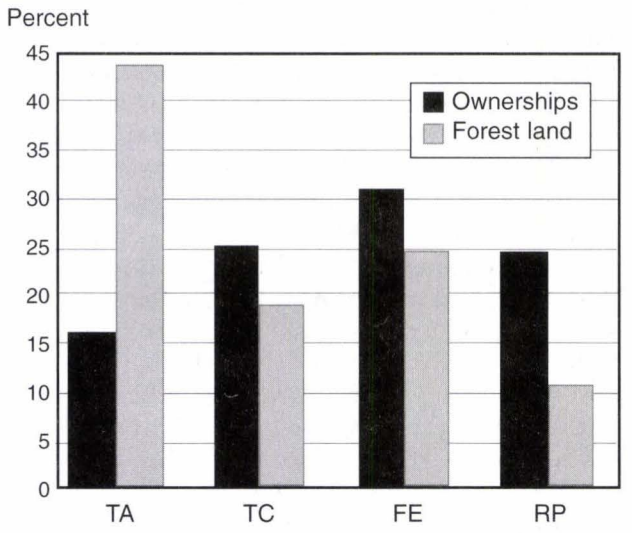

Figure 10.2 — *Proportions of NIPF owner types and forest land holdings in the Missouri Ozarks (Lewis 1979).*

Some attributes were common to all NIPF owner types. Everyone interviewed, except one person, appreciated wildlife. They recognized the potential for land and resource value appreciation; all were interested in profit, but it was not a primary motivation for all.

NIPF OWNER DECISIONS

A whole host of factors influence landowner decisions (table 10.3). In previous studies, we explored different motivations and objectives for holding forest land, and we have couched these in table 10.3 in terms of personal characteristics. In addition, owners place a group of consumptive demands on the land. All these factors go towards shaping an owner's land ethic, in the context of religion, family background and experiences, and education.

A representation of how people make decisions (Kurtz *et al.* 1983) is illustrated in figure 10.3. There are four key times with respect to owners' motivations and their application of management practices. Early on, there are management opportunities when a person just obtains some land. Market opportunities and management attitude affect owners' perceptions of management opportunities. This is when education and technical assistance become really important in influencing owners' perceptions. Next, given owners' consumptive demands, they will sort

Table 10.3 — *Factors affecting NIPF owner management attitudes*

Motivations	Objectives	Personal characteristics	Consumptive demands
Financial return Investment Satisfaction Residence Social responsibility	Timber Recreation Wildlife Preservation Fuelwood Grazing	Age Education Income level Occupation Family Experience Capability Peer acceptance	Pride Fuelwood Recreation Hunting Windbreak Soil erosion Nature Release

Source: Kurtz *et al.* 1983.

through the situation and identify what they consider practical management alternatives. That is where various types of financial incentives enter into the decision framework.

Education and financial incentives are significant at different times in the landowner's decisionmaking process. The decision process starts over every time ownership changes, and this process can be drawn out or compressed depending on the owner's experience. Another aspect that is often not considered is that NIPF owners are sovereign. They make the decisions to maximize their utility however they see it. So how is a balance achieved between society and the NIPF owner? Foresters and others providing education and technical assistance to NIPF owners need to better understand the owners' situation, problems, and opportunities. What are their motivations, goals, objectives, and aspirations? These individuals need to be made aware of their need for better management—we do not do a good job in this respect. Programs should be developed that will educate owners, create an owner-centered desire for management, and assist owners with on-the-ground application of practices. We cannot afford to just give owners a

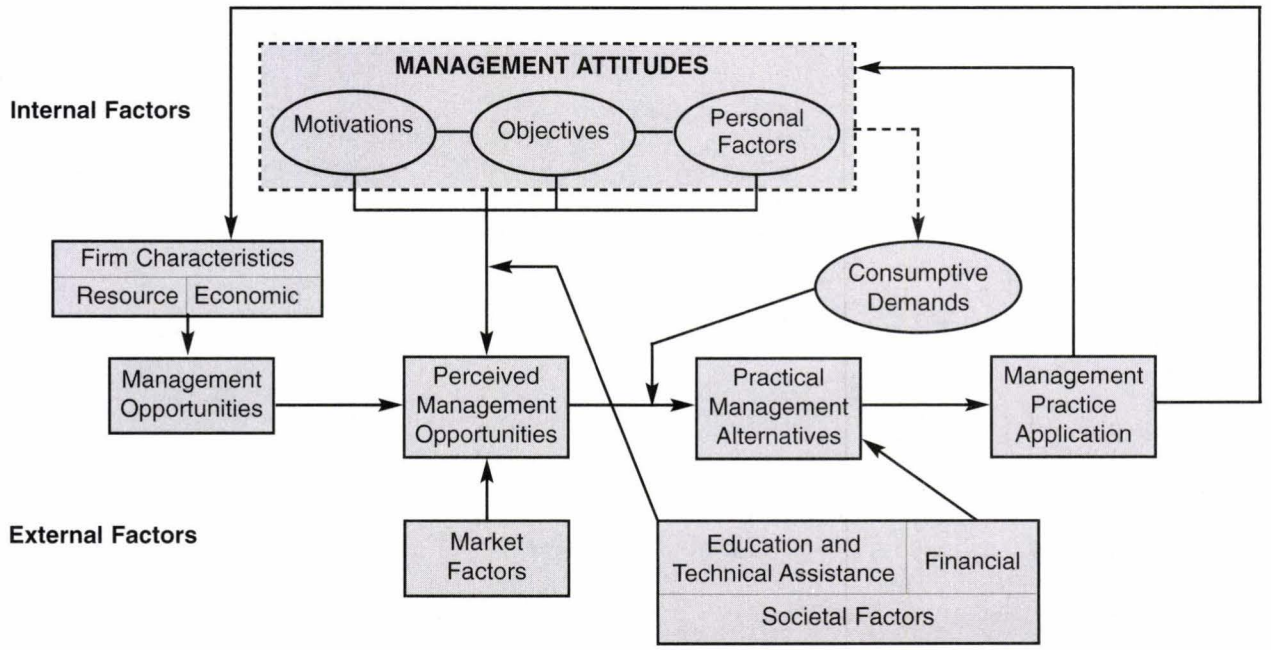

Figure 10.3 — *NIPF owner decisionmaking framework (Kurtz* et al. *1983).*

plan followed by the excuse that we are too busy for followup with subsequent contacts.

LANDOWNER INFORMATION

Landowners need forest management information of a kind and type that is both useful and understandable. Dwyer and Kurtz (1991) attempted to answer the question, "What is the financial difference between a diameter limit cut instead of management of the resource over a sustained period of time?" We found that a 40-year-old northern red oak stand on a 60-year-rotation harvest with a 16-inch diameter cut would yield $115 per acre, compared to $78 if the owner just did an improvement cut. There is a $37 per acre difference, but the stand is wasted for the future. However, a selection cut now and 10 years later, and then a final harvest in 3 more years, discounted to the present at 4 percent would give a difference of $201 in present value. The amount received in 23 years, in the final harvest, would be over $1,000 per acre. People need this information in an understandable way to make the best decisions.

IMPLICATIONS

Privately owned forest lands in the United States, as well as in Missouri, are held in a dynamic state, both in terms of ownership and use. The emerging land use pattern is the result of a complex mix of individual owner management decisions as well as ecological factors. Long-term ecological sustainability of Missouri's forest resource begs for attention. The call is for generation of science-based, objective information on the benefits, costs, and impacts of management decisions, both on an individual ownership basis, and on a broad scale. But, perhaps, an equally great need is for private forest owners, in concert with public resource-holding management agencies, to view their decisions in a corporate fashion, i.e., in an ecological sense at the landscape level.

We need to develop new ways of examining decisions that provide readily understandable information to the non-scientist, providing management information to the decision-makers about their resources as well as the impacts of their decisions on others. Furthermore, we need ways to encourage private landowners with disparate objectives to work together for the common good. Perhaps through the development and adaptation of comprehensive, interdisciplinary decision models coupled with interactive geographic information system technology, a common bond can be forged.

CONCLUSIONS

Many are familiar with Aldo Leopold's writing and philosophy. In his well-known book, *A Sand County Almanac*, he talked about an ecological conscience, a land ethic where humans behave towards nature in a social manner (Leopold 1949). In this respect, people engage with nature in a civil fashion. He described conservation as a state of harmony between humans and land. According to his philosophy, conservation reflects the existence of an ecological conscience that reflects a conviction of individual responsibility for the health of the land. Leopold divided people into two groups. Group A regards the land as soil with its function as commodity production while Group B regards the land as soil with a somewhat broader function. One can well imagine that Leopold would feel that Group B has the ecological conscience. People inherently are going to make the best decision for themselves and for society if they have good information.

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Missouri Citizen Attitudes Toward Forest Resources: Issues Related to Forest Land Management and Sustainability

Sandy Rikoon[1] and Douglas Constance[2]

Abstract.—In 1996, we surveyed 1,200 Missouri citizens on their opinions on issues connected with private and public forest lands in the State. This article assesses the findings from the overall group and compares the opinions of forest owners and non-owners and of urban and rural respondents. The overall group supports a holistic conceptualization of sustainability that includes environmental, social, and economic objectives. While as a group, they place highest importance on the ecological and physical dimensions of forests, they also support economic and recreational uses of forest land. Respondents are more satisfied with the management of public forests than privately owned land, although there are some large gaps in their knowledge of who owns which forest lands in the State. The majority feel management on private lands can be improved and support appropriate programs to improve management of private forests. Any attempt to impose strong regulatory mechanisms to achieve the goals of sustainability, however, would be met with strong opposition and public conflict. Support for regulation of private forest lands is likely to find more support in urban areas than in rural areas or among forest owners across the State.

INTRODUCTION

Understanding citizen attitudes, values, and beliefs about the environment and natural resources is critical to the development of successful public policies and programs. Success depends not only on the acknowledgment of public sentiments but also on the ability of policymakers and institutions to develop effective and equitable means for wider citizen input, participation, and evaluation. Discussions on sustainability programs are especially linked to citizen involvement because critical decisions must be made on such issues as what is to be sustained, why it should be sustained, and how sustainability will be measured. We do not believe that environmental policy or public programs should normally be constructed on the basis of public plebiscites. But we also recognize that the Missouri landscape is littered with the remains of recent public programs and policy strategies (e.g., Missouri Department of Conservation's Coordinated Resource Management Program and the failed attempt to establish an Ozark Plateau Man and the Biosphere (Geodeke and Rikoon 1998, Rikoon 1998)) that met their demise in part for not taking into account the sensibilities of Missouri citizens.

In this essay, we discuss citizen opinions on issues related to forest sustainability that were included in a recent statewide survey of Missouri residents (Constance and Rikoon 1997a, b). Although the research instrument itself was not targeted at sustainability *per se*, a number of its questions document citizen attitudes toward relevant objectives and ways to attain them, as well as opinions on dimensions critical to the development of policies aimed at enhancing forest sustainability. Specifically, this paper addresses citizen

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opinions on the importance of ecological and economic functions of forests, the possibilities of attaining multiple sustainability objectives, assessments of present management performance, and the role of the state as regulator of private lands. More briefly we also discuss citizen knowledge of forest resources and ownership patterns and public attitudes toward the Missouri Department of Conservation.

In 1996 we surveyed 1,200 Missouri citizens regarding a broad range of issues related to forest management in the state. The study was primarily a replication of a survey undertaken by Bruce Palmer (1993) as part of his M.S. thesis in forestry at the University of Missouri-Columbia. Both studies divided the state into eight rural and three urban districts. The rural districts roughly follow natural ecological divisions within Missouri. The three urban districts are the Kansas City and St. Louis metro areas and Greene County, which includes the city of Springfield. Both studies used telephone survey formats whereby we interviewed approximately 100 persons in each rural region and 133 persons in each urban area. We identified potential participants through use of a random digit dial sampling of all phone exchanges. Enumerators employed a Troldahl-Carter-Bryant protocol to identify respondents over 18 years of age and to ensure equal male and female participation. Interviewers ultimately completed a total of 1,206 interviews in 1996, with an overall response rate of 61 percent.

In this essay we present and analyze the responses of four overlapping populations. The "total sample" includes all 1,206 persons. We designed the research collection plan primarily to provide information for comparative regional analyses, and we do not weigh our results here to provide a composite portrait of the state. A few core demographic comparisons between the research sample and the overall Missouri population, however, should be noted. Our research design naturally resulted in a total sample that includes an overrepresentation of rural residents. Our group of respondents is very close to statewide census of age categories for residents over 18 years of age. As is typical of random sample phone surveys in general, we slightly under-represent people in the lowest education category (i.e., less than a high school diploma) and in the lowest income category (i.e., household income under $10,000 per year). The forest survey sample parallels state percentages in terms of high school and college degrees, and for low-middle to upper-middle income groups.

In addition to the total sample, we contrast the responses of urbanites (N=347) and rural residents (N=854). Urbanites are defined as those respondents who identified themselves as living in towns or cities with a population greater than 10,000; rural people identified themselves as living on farms or in communities of less than 10,000 population. Finally, we will often refer to the subgroup of our sample that identified themselves as forest owners (n=258). These are individuals who confirmed ownership of at least 10 acres of forest land. Other characteristics of this group are as follows:

- Mean size of total forest acres owned is 73; range is 10 to 600.
- Owners live an average of 12 miles from their forest land; 52 percent live on this land and only 7.8 percent live more than 50 miles from their forest acres.
- Owners are predominantly rural, older, and more likely to be male (58 percent), although females own an average of 90 acres versus 60 acres for males.
- 20 percent of owners have sold more than $1,000 of wood products from their land.
- 17 percent of owners have used a professional forester for management assistance.

We selected these subgroups for analysis in part due to discussions in previous studies on contrasting social predictors of environmental attitudes and beliefs. In terms of urban/rural comparisons, a review of studies completed prior to 1980 (Van Liere and Dunlap 1980) found inconsistent correlations between community size and people's levels of environmental concern. Research in the 1980s and 1990s, however, suggests that urban residents are more "environmentalist" in their views than are rural residents (Constance and Rikoon 1993, Constance *et al.* 1996, Freudenberg 1991, Larsen 1993, Palmer 1993, Rikoon and Constance 1997). There are often critical differences among these studies in how they define "environmentalism" or "environmental concern." Some scholars (Dunlap and Olsen 1984, Rohrschneider 1990, Arcury and Christianson 1990) stressed individual concerns about the seriousness of possible environmental problems, and in most cases

found rural/urban differences. Other studies found less difference in individual concerns for the preservation or restoration of environmental quality, but greater variation in attitudes toward public policies and strategies to restore or maintain environmental quality (Rikoon 1998, Freudenberg 1991). Some researchers (Kellert 1984, Jones and Dunlap 1992) reported that present location is not conclusive, but they suggested significance is found in knowing the area in which respondents grew up and received their early socialization and orientation to environmental issues. As with most attempts to profile the demographic and social bases of environmental attitudes, the impact of current residence location remains mired in methodological and analytical confusion and contestation (Van Liere and Dunlap 1981, McMillen *et al.* 1997). But given the rich history both in the literature and in the annals of sometimes contentious rural/urban conflicts in Missouri, we believe it is important to examine possible differences between these groups.

Forest owners comprise a key group of social actors in any public effort to achieve sustainability objectives in Missouri's wooded regions. Again, there are suggestive trends in previous studies. One school of thought suggests that people who live on the land and have occupations in farming or forestry have a more "extractive" orientation toward the land and therefore may be less supportive of environmentalist agendas (Freudenberg 1991). Filson (1993), Freudenberg (1991), and Lowe and Pinhey (1982) found this relationship in agriculture. Previous studies in forestry tend to show the same patterns (Fortman and Kusel 1990, Palmer 1993), although the correlations and differences are often rather weak and may be explained by other variables. Interestingly, while most studies show that public sector professionals in middle class and upper class white-collar occupations have more pro-environmentalist attitudes, only a few studies have combined professionalism and extractive industries. The research of Fortman and Kusel (1990) is of interest because it documented lower environmental concern and higher pro-commodity attitudes among Forest Service employees than in the public at large.

DATA DISCUSSION

Forest Resource Objectives

We asked Missourians to rate the importance of various environmental, economic, and social functions of forest land in general (fig. 11.1). Respondents gave the three environmental objectives the highest percentages of "very important" ratings. More than 50 percent of all respondents rated both social objectives—at the bottom of figure 11.1—and the production of lumber and wood products as very important, and slightly more than a third gave strong importance to the fact that people earn their livings from forest-related jobs. Although the social and economic reasons received significantly lower frequencies of "very important" ratings, if one adds in ratings of "moderately important" (shown in gray), then all the variables become at least moderately important to super majorities.

The white parts of these bars, which capture returns of "not very important" and "not at all important" together, never include more than 15 percent of responses. There is remarkable consistency in respondent opinions between 1993 (Palmer 1993) and 1996; none of the absolute ratings of importance changed in a significant fashion over this period.

Urban, rural, and forest owner ratings reveal a few additional trends (fig. 11.2). Urban and rural frequencies of high importance reveal only minor and statistically non-significant differences on environmental and social objectives. There was significantly higher support in rural areas for the economic and material functions of forest products. While the tendency of rural residents to assign higher importance to economic functions is to be expected, the lack of significant differences between the two groups on aesthetic, recreation, and environmental reasons runs counter to most recent research on urban/rural differences.

Forest owner ratings of importance did not differ significantly from those of non-owners (Constance and Rikoon 1997a) on any of the variables. Again, these results are somewhat surprising. They may suggest that forest owners in Missouri are not principally interested in the economic and use values of their land or, more likely, that owners recognize that multiple values or utilities are satisfied through forest tracts.

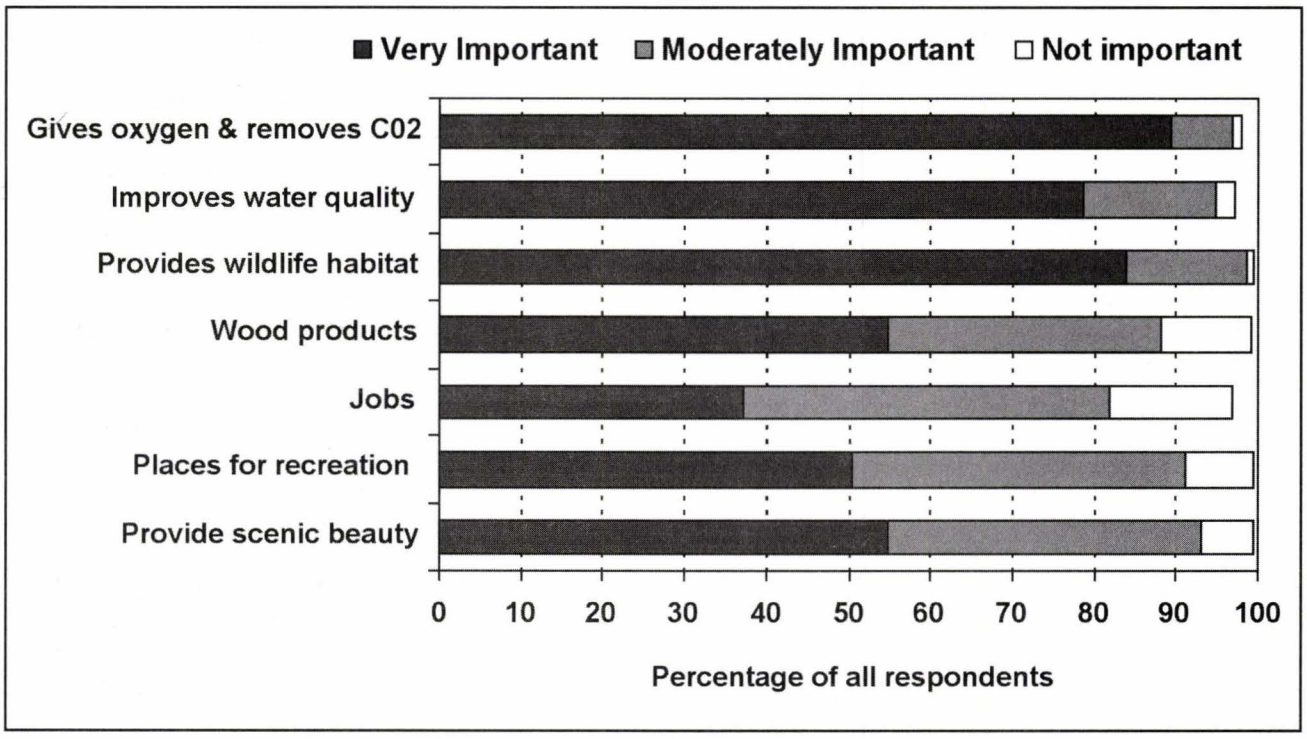

Figure 11.1—*Ratings of reasons why forest land is important, by total sample.*

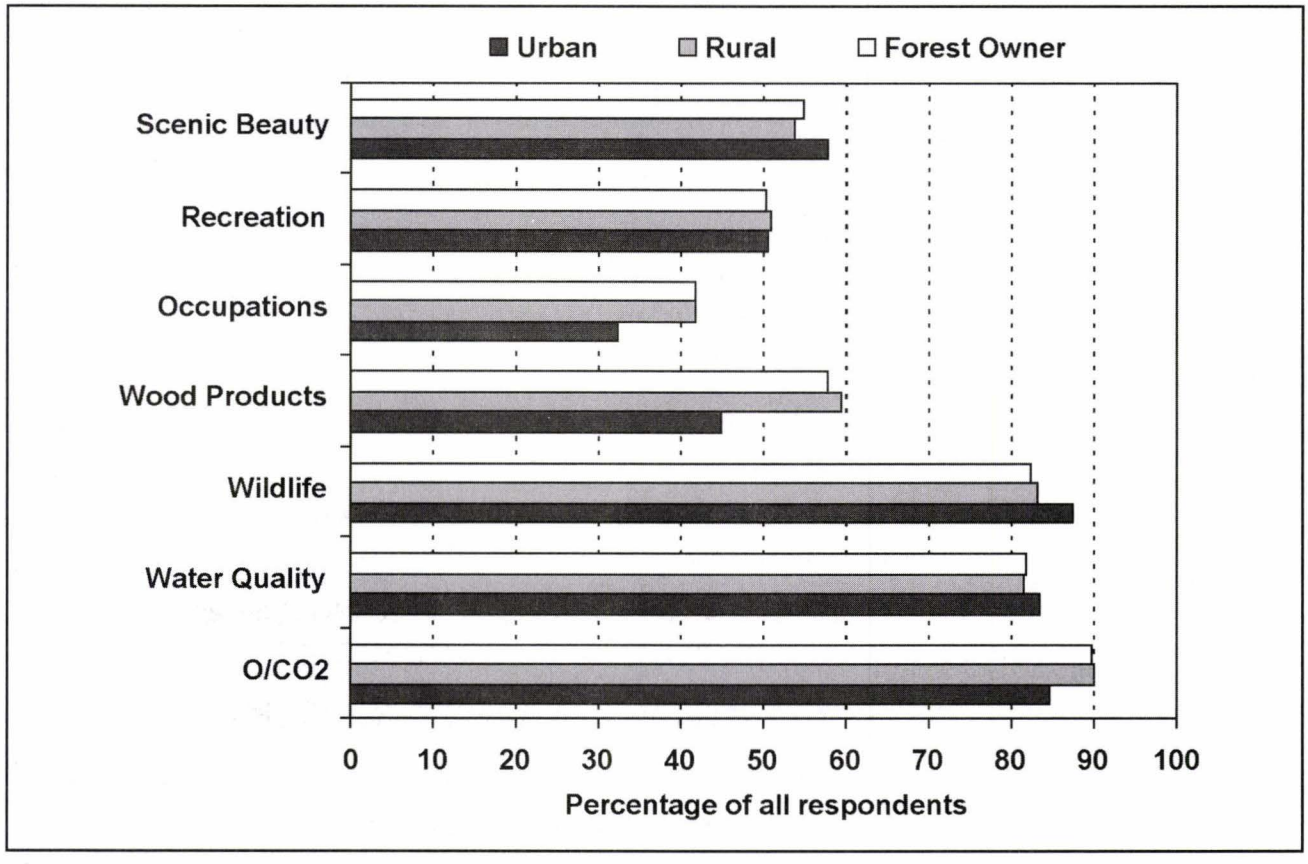

Figure 11.2—*Ratings of reasons why forest land is very important, by respondent group.*

We also asked citizens specifically about the importance of "forest land owned by either local, state, or federal government." In many respects, the response patterns (fig. 11.3) parallel those given for forest land in general (although the functions evaluated in the two questions are not identical). The three ecological functions related to public forests—"places for fish and wildlife habitats," "the role of forests in providing clean streams," "and place to preserve diversity in plant and animal life"—received the highest frequencies of "very important" from the total sample and from each subgroup. Urbanites rated each of the environmental uses higher than the other subgroups and were the least concerned about timber production and access to forest land. Compared to urban residents, rural residents and forest owners rated timber production significantly higher as an important function of public forests, but less than a majority expressed strong support for this economic use. Finally, we should note that citizens ascribed equally high levels to the environmental functions of public lands and forests in general but tended to give lower ratings to the recreational, social, and economic importance of public lands. It is difficult to suggest a single cause of these differences. They may simply reflect the relatively small proportions of public forests in the state and consequent lower citizen contacts with these acres. It is also probable that the public's worldview about public forest lands in general includes lower expectations regarding economic benefits and greater stress on the environmental and social goods of public ownership.

The overall results on forest land importance suggest that all respondent groups are interested in a holistic conceptualization of sustainability that includes environmental, social, and economic objectives. While respondents placed highest importance on the ecological and physical dimensions of forests, they also supported economic and recreational uses of forest land. These returns reveal widespread support for a conceptualization of sustainability close to that recently offered by J.A. Helms (1998), who defined it as "the capacity of forests . . . to maintain their health, productivity, diversity, and overall integrity . . . in the context of human activity and use."

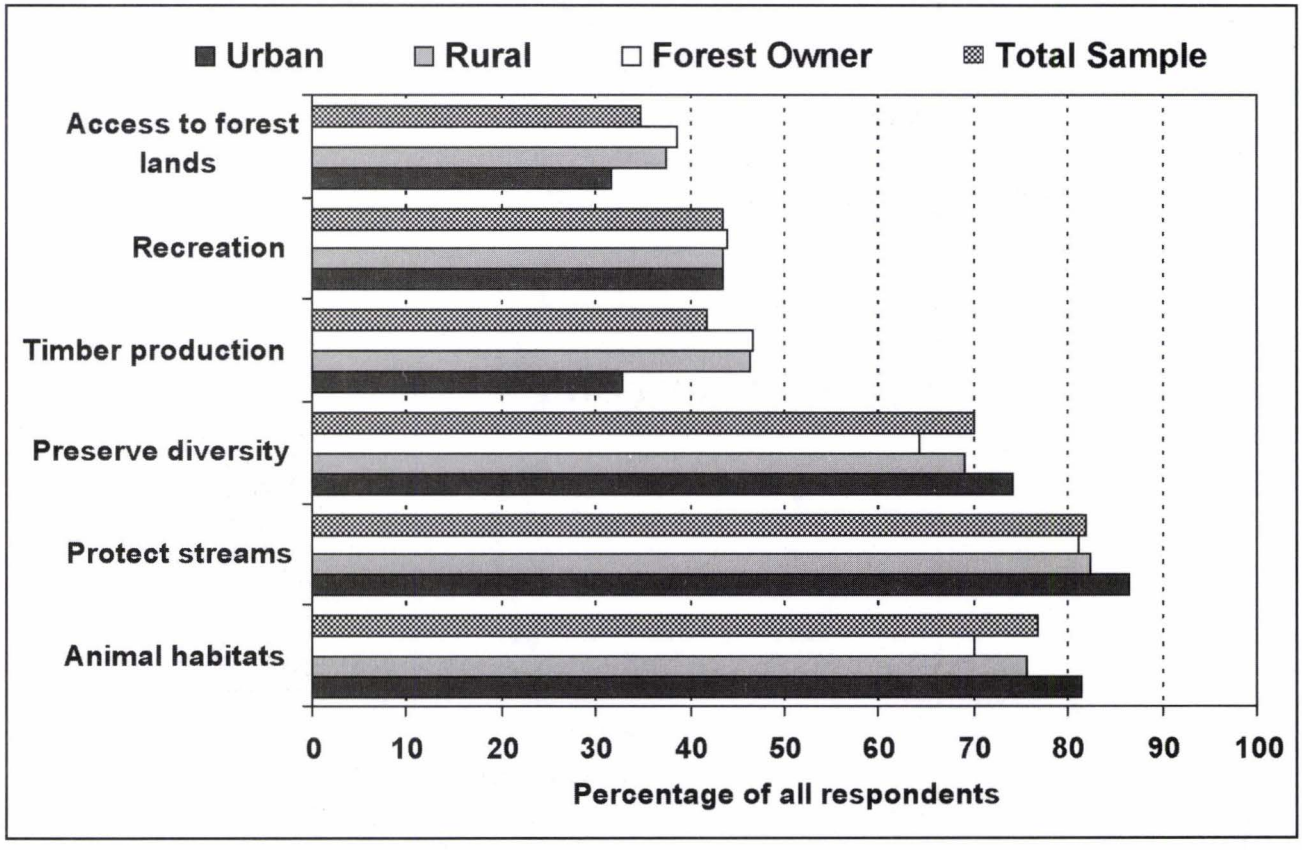

Figure 11.3—*Ratings of reasons why public forest land is very important, by respondent group.*

ACHIEVING MULTIPLE OBJECTIVES

Various survey questions addressed the issue of balancing environmental protection and economic development. It is one thing to desire more holistic forest resource management and perhaps something else altogether to believe it possible to achieve multiple objectives. Figure 11.4 reports group response patterns to the question "Most of the time, do you think environmental protection and economic development can go hand in hand, or that we must choose between environmental protection and economic development." With very little differences in their responses, about 70 percent of individuals in each group reported that the two agendas can "go hand in hand"; about one-fifth of interviewees felt we must "choose between them."

We performed several multivariate logistic regressions on this dichotomous variable to see if certain factors could predict the belief that we must choose between the two (Constance and Rikoon 1997a). Four variables were significant in our final model—urban residence, lower education, lower income levels, and lack of trust in the Missouri Department of Conservation (MDC). However, these factors explain only a minority of the variance in the responses.

A rather similar survey question posed two contrasting statements to respondents and asked them to choose which best reflected their beliefs (fig. 11.5). One statement claimed that the only way to preserve wildlife and forests is to prevent development and to restrict most human activity in these areas, while the second declaration avowed we could protect those resources while also using them "for the benefit of our economy and the public." The response patterns are parallel to returns to the previous question. About three out of every four interviewees indicated we can do it all. Urbanites were slightly more likely to suggest we had to restrict economic activity, but only 20 percent indicated this belief. Respondents who favored restricting activities tended to be individuals who also favor State regulation—a variable we will discuss in a moment—have higher incomes, and little or no trust in MDC.

In essence, most respondents believe not only that multiple objectives can be obtained, but also that in most cases we should not have to choose between environmental protection or economic objectives. Any policy or program proposal that polarizes the issue of sustainability by championing or privileging only a single set of objectives is likely to meet with

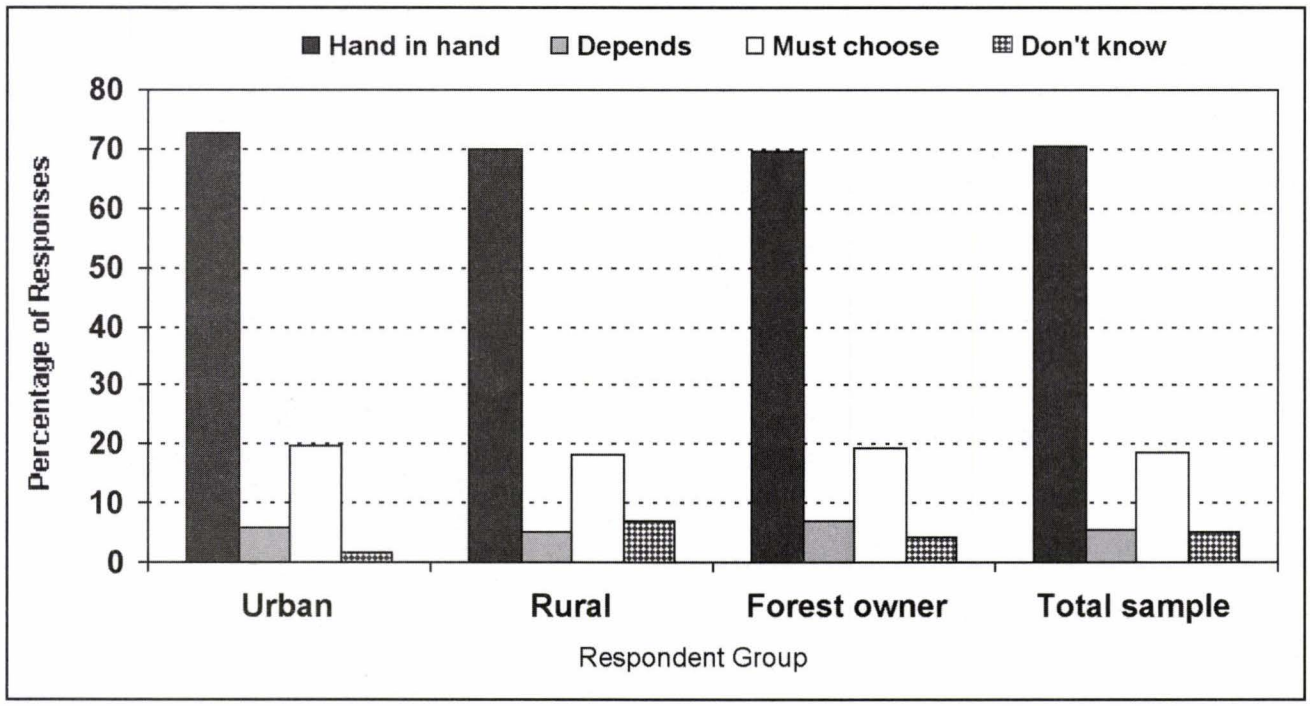

Figure 11.4—*Environmental protection and economic development can go hand in hand or we must choose, by respondent group.*

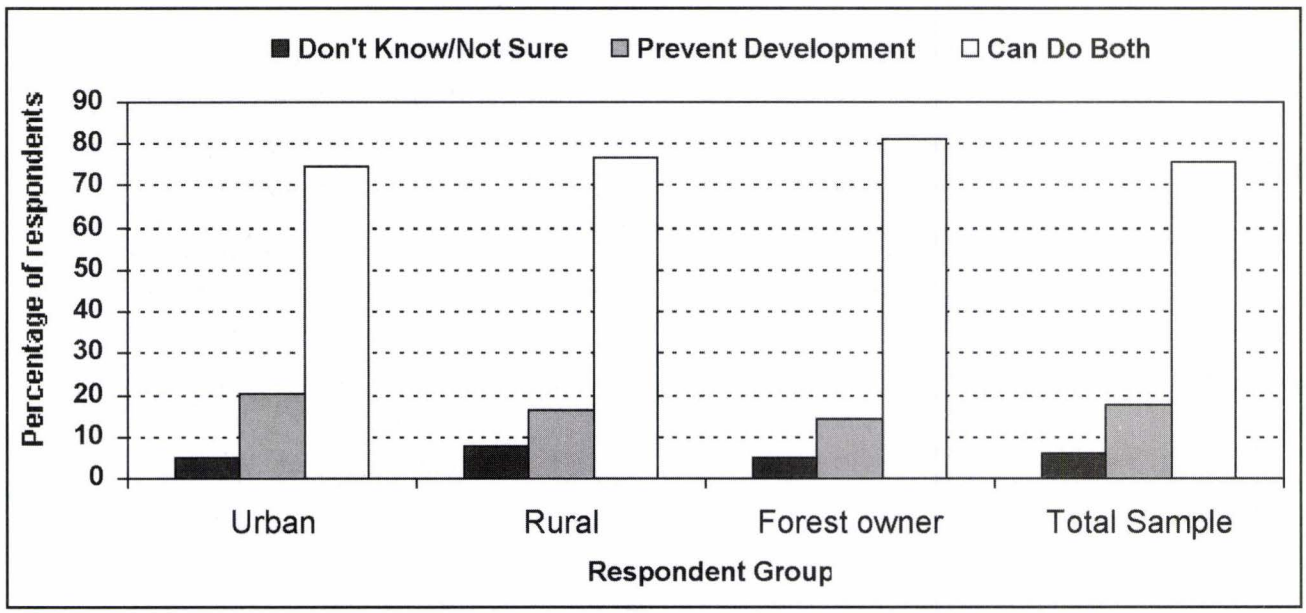

Figure 11.5—*Preference between constrasting statements on ability to combine environmental/economic objectives or need to curtail human activity to meet environmental goals, by respondent group.*

opposition from citizens who favor multiple objectives and believe they can be achieved.

Citizen support for attaining multiple objectives is attached to both private and public forest lands in the state. We have discussed the fact that higher percentages of residents recognize the social and economic uses of private lands yet also continue to express preferences for a multidimensional approach to public forests as well. An example of this desire is portrayed in table 11.1, which reveals the responses to two questions about the management of public forests. One question asked respondents to assess the statement that "Portions of public forests should be set aside where timber cutting and vehicles are not allowed" and a second inquiry asked for their agreement with the policy option that "Trees on public forest land should be cut and used rather than allowed to die and rot." More than 80 percent of the overall sample agreed with both these statements, although a means test analysis shows a significantly higher level of support for the "set aside" option. In essence, almost twice as many people strongly supported this preservationist option as supported the harvest of older timber. On the other hand, only minorities of respondents opposed either proposal. The highest level of opposition was found in urban disagreement with tree harvests, and the level of disagreement was less

Table 11.1—*Opinions (in percentages) on policy options concerning public forest lands, by respondent group*

Question	Strongly Agree	Agree	Disagree	Strongly Disagree
Portions of public forests should be set aside				
Total sample	45.3	40.3	11.7	2.6
Rural	40.8	42.4	13.7	3.1
Urban	56.3	36.1	6.7	0.9
Forest owners	37.3	44.8	13.9	4.0
Trees should be cut rather than die and rot				
Total sample	24.3	58.4	15.9	1.3
Rural	25.5	59.4	13.8	1.2
Urban	21.0	56.5	21.0	1.5
Forest owners	23.7	63.5	12.4	0.4

than one-quarter of the urban sample. As expected, rural and forest owner responses were less supportive of set-asides and more favorable towards the economic option, but again the concordance between the groups was much larger than their differences. In terms of policy implications, these responses suggest that targeted programs based on specific combinations of natural resource and cultural resource conservation have the best chance of contributing to the attainment of sustainability objectives in Missouri.

We also asked citizens, "When it is impossible to find a compromise between economic development and environmental protection, which do you believe is more important?" As shown in figure 11.6, about two-thirds chose environmental protection as the more primary objective. Urban-rural and forest owner differences were a bit more pronounced, with the latter groups showing slightly higher percentages favoring economic development, or at least opting for a contextually dependent decision. On this issue of choosing between the two alternatives, overall support for environmental protection rose significantly from about 50 percent in 1993 to 67 percent in 1996, while support for "economic development" dropped from 24 percent to 14 percent. Multivariate analysis indicates that other demographic predictors of people who choose "environmental protection" are female gender and trust in MDC (Constance and Rikoon 1997a).

In summary, the vast majority of respondents believe that "economic development" and "environmental protection" can go "hand in hand." In fact, there has been an increase in this view over the past few years. What changes does this belief in achieving mixed-use objectives reflect? Perhaps most people now realize that polarized rhetorical debates about having to choose between jobs and the environment are usually ones more of morality and ideology than of practice and empirical evidence. In Missouri we may also be witnessing the consequences of some very shining public and private management projects demonstrating the compatibility of ecological and economic objectives. Interestingly, one of the most common predictors on these questions is trust in MDC. People who do not trust MDC are by far the subgroup most supportive of a contradictory relationship between economics and the environment. This lack of trust leads actually to two contrasting positions. Some individuals believe MDC has become too environmental and undersupportive of economic development. And other respondents, most of whom are urban, find MDC to be too involved in economic activities, and believe we need to prevent development and restrict human activities. These results may suggest MDC is doing things just about right. The majority of Missourians believe in both a comprehensive menu of functions for Missouri forests and that this agenda is achievable.

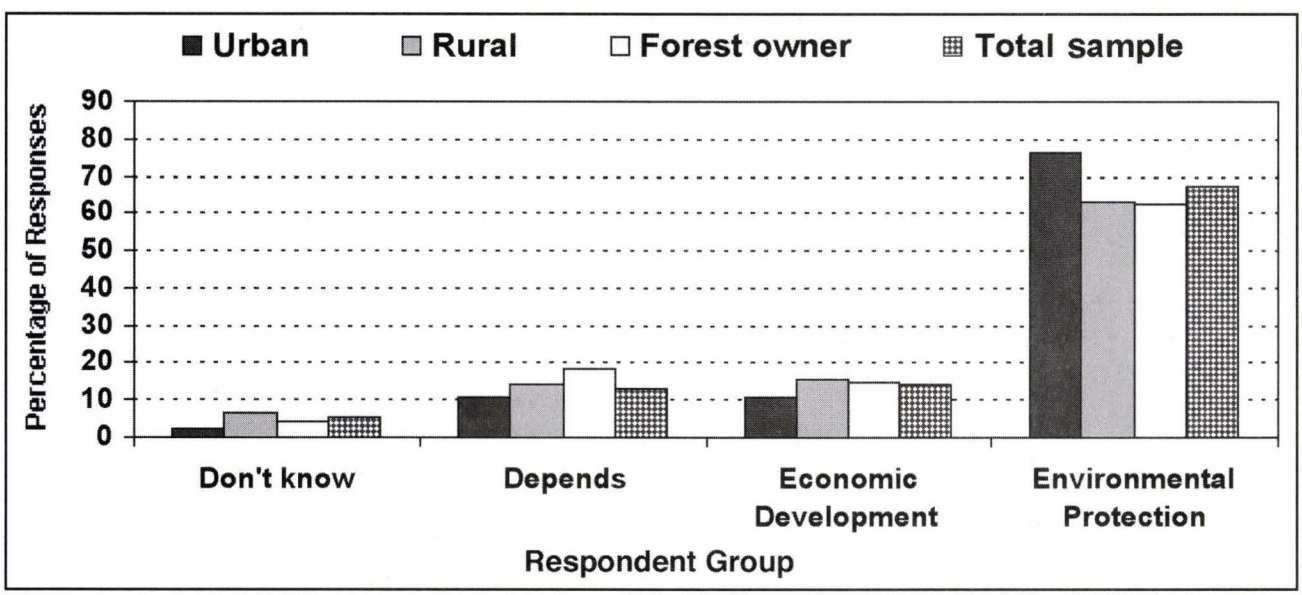

Figure 11.6—*If unable to reach a compromise, do you believe environmental protection or economic development is more important, by respondent group.*

RATINGS OF PRESENT MANAGEMENT OF FORESTS

Given respondent attitudes and values about the functions of forests and their desire to meld environmental, economic, and social objectives, how do individuals rate the present management of forest land in Missouri? And, importantly, how do they feel about the use of increased regulation on the part of the State as a strategy to achieve valued objectives on privately owned land?

Our research over the past decade, albeit largely concerned with non-forest resources, suggests we should not confuse widespread support for environmental objectives with agreement on how those objectives should be achieved (Rikoon 1995, 1998). Consensus agreement for the objectives of a holistic sustainability of natural resources denotes no unanimity when it comes to plans for implementing those goals. A perfect example of this in Missouri are the conflicts often attached to the use of regulation as a strategy for achieving desired environmental protection, particularly controversies grounded in citizen perceptions of the connections of regulatory programs to the degradation of private property rights, local control, and land access and use.

First, we asked respondents for their level of agreement with statements that public and private forest lands are being wisely managed. There was fairly high consensus within all groups that public forests are wisely managed (fig. 11.7). Forest owners (74.1 percent) were most likely to either "strongly agree" or "agree," in contrast to 64.1 percent of rural residents and 63.5 percent of urbanites. A substantial percentage of respondents in each group answered "don't know" or "not sure."

When we posed a similar statement regarding the quality of management on private forests, the approval ratings dropped below 50 percent for all groups, accompanied by an increase in the level of uncertainty (fig. 11.8). The distribution of responses for each group is again very similar. Forest owners (46.1 percent) were most likely to "strongly agree" or "agree" that private forest land is wisely managed, followed by rural people (44.0 percent) and urbanites (43.1 percent). Substantial percentages of rural individuals (16.4 percent), forest owners (10.1 percent), and urbanites (20.7 percent) reported they are "not sure." In part due to their relatively lower levels of uncertainty over this statement, forest owners had the highest frequencies of both positive and negative evaluations. With 43.8 percent of owners disagreeing about the adequacy of private land management, the group clearly acknowledged that in some cases private owner management needs improvement.

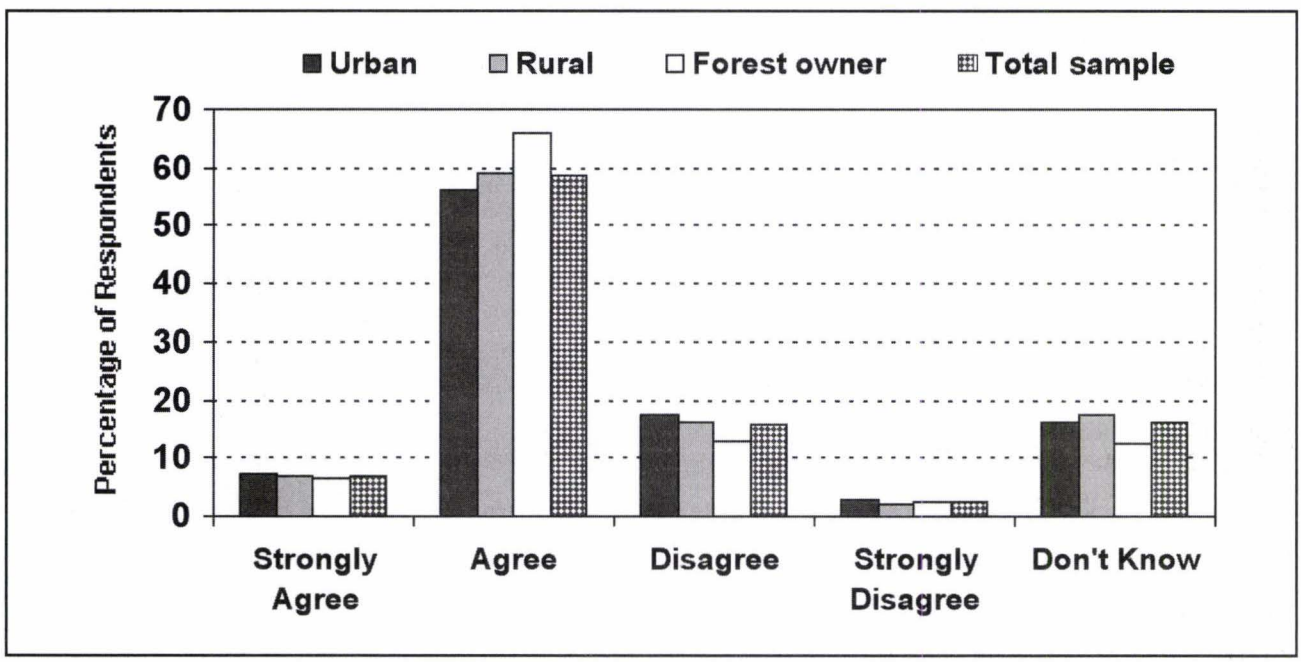

Figure 11.7—*Agree with statement that public forest land in Missouri is wisely managed by respondent group.*

Based on responses to these two questions, we can conclude that respondents generally believe public forests are better managed than private forests. We should mention an important caveat here. As will be discussed later, Missouri citizen ideas on these subjects must be viewed in the context of rather large gaps in their knowledge about who owns what forest lands in the state. In fact, a majority of people seem rather poorly informed about which lands in the state are private and which are public and about how much of the forest is privately or publicly owned.

We did not design this survey to discover why so many people are unhappy about management practices on privately owned land. However, 30 to 40 percent in each group identified activities on forest land in general that concerned them (table 11.2). Respondents appear anxious about both specific management practices (e.g., types of logging) and the loss of forest land due to land conversion and development. Paul Gobster (1994: 122-123) wrote that acceptance or rejection of forest management is based in large part on a "scenic aesthetic that is narrowly defined and largely visual in nature." He further noted that three critical cultural legacies in this regard are "attraction to an idealized nature; an orientation to a static, visual mode of landscape experience; and an aversion to disruption and change." Clearly the kinds of activities noted by respondents conflict with individual and social group norms related to such idealized notions of landscapes and associated appropriate behaviors. Land conversion and change are of concern to all groups. Some intergroup

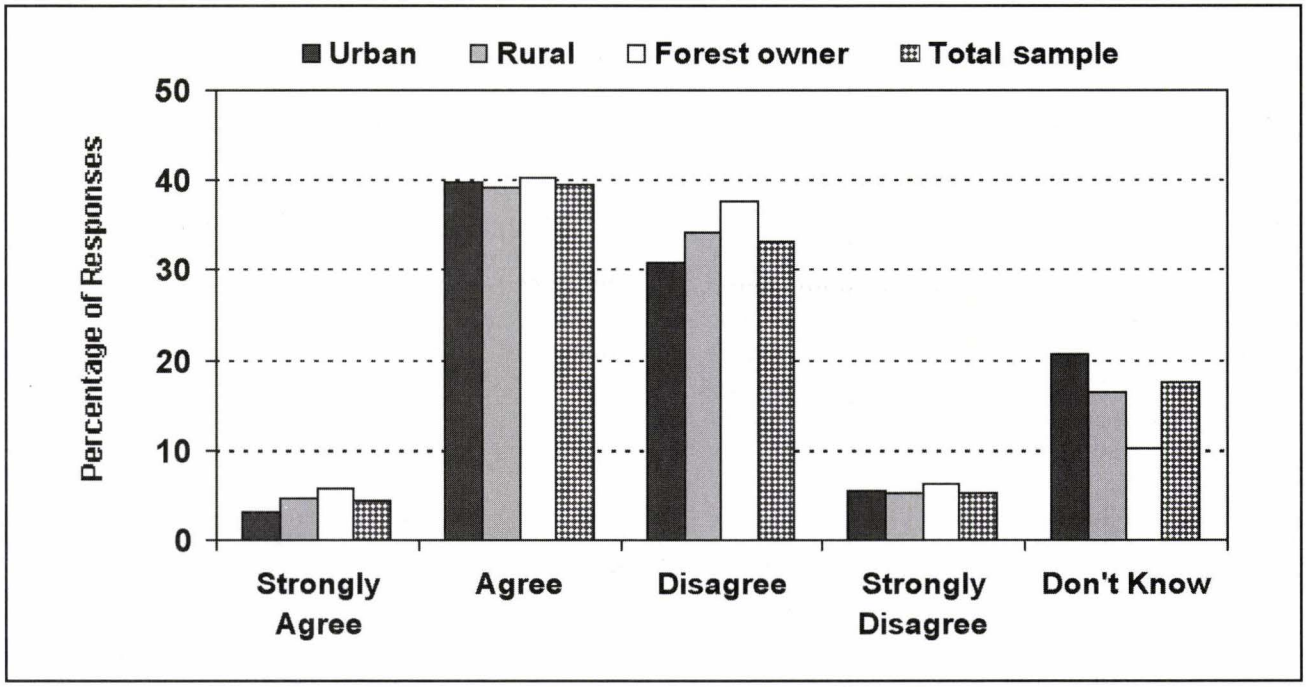

Figure 11.8—*Agree that private forest land in Missouri is wisely managed, by respondent group.*

Table 11.2—*Noted activities (in percentages) of concern in forest, by respondent groups*

Type of activity	Total sample (N=455)	Urban group (N=115)	Rural group (N=339)	Forest owners (N=127)
Logging	23.6	13.3	26.7	33.6
Land clearing/conversion	19.3	16.8	20.1	15.5
Urban development	9.5	15.9	7.5	20.7
Litter/dumping	10.2	18.6	7.5	4.3
Insects/diseases	9.5	3.5	11.5	1.7
Forest fires	5.2	5.3	5.2	3.4
Habitat loss	1.9	0.9	2.3	1.7
ATVs	2.8	7.1	1.4	1.7

differences, including more frequent citation of logging activities by forest owners and urbanite citations of dumping and litter, reflect differences in their experiences and encounters, as well as variation in cultural attitudes and perceptions.

SHOULD THE STATE REGULATE PRIVATE FOREST LANDS?

We asked all respondents if they agreed that the state should regulate private forest land. This question is important to the issue of forest sustainability for two primary reasons. First, regulation is an increasingly used policy alternative for the achievement of sustainable forestry objectives. Second, the issue of regulation is relevant in the context of preferred policy strategies for meeting perceived environmental problems. In this case, the question can be asked: If a majority of citizens do not claim private forests are being wisely managed, then what are the levels and social bases of support for State regulation of these lands?

There are important significant differences between the three groups on this issue (fig. 11.9). One-half of urbanites (50 percent) strongly agreed or agreed that the state should regulate private forest land; majorities of rural people (57.1 percent) and forest owners (65.8 percent) disagreed strongly or disagreed with the statement. In other words, while urbanites are split evenly on the topic of State regulation of private forests, rural people and forest owners are mostly opposed to it. The fact that substantial minorities of both rural people (37.8 percent) and forest owners (29.2 percent) favor State regulation of private forest management, however, indicates at least a small basis of popular support for such efforts.

There were some changes in total sample opinions between 1993 and 1996 (Palmer 1993, Constance and Rikoon 1997a). Support increased for the wise management of public forest and slightly decreased for the wise management of private forest land, although in neither case do the mean scores change significantly. Overall responses to the issue of State regulation changed significantly, in this case *against* the idea of State regulation. Disagreement with regulation increased from about 45 percent of our total sample in 1993 to 56 percent in 1996.

Forest owners have also changed their opinions somewhat since 1993 (table 11.3). For example, more forest owners in 1996 (72.4 percent) than in 1993 (62.2 percent) strongly agreed or agreed that public forests are wisely managed. Virtually no change has occurred on the topic of the quality of private forest management. On the issue of State regulation of private forests, the overall percentages for "agree" and "disagree" remained the same, but

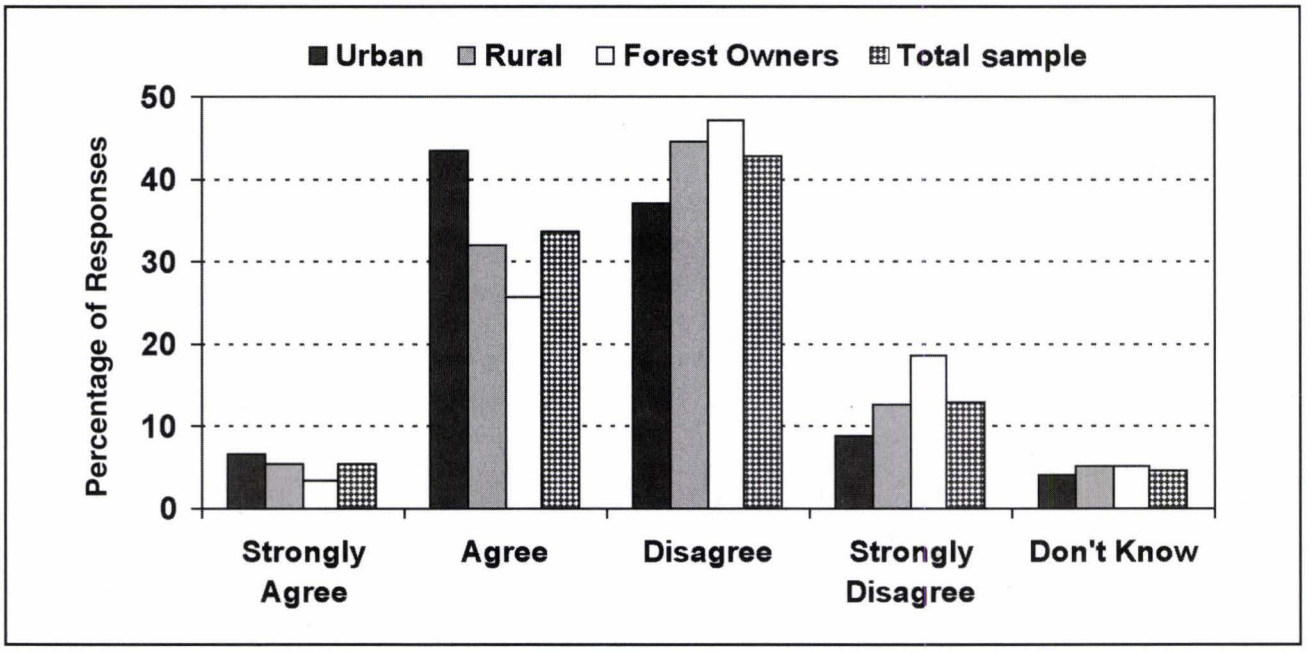

Figure 11.9—*Agree that forest management on private land should be regulated by the state, by respondent group.*

Table 11.3—*Comparison of 1993 and 1996 forest owner opinions on the quality of public and private forest management and State regulation of private forests*

Issue	Year	Strongly agree	Agree	Disagree	Strongly disagree	Not sure
Public forest is wisely managed	1996	6.6	65.8	12.8	2.3	12.5
	1993	7.9	54.3	20.7	2.4	14.6
Private forest is wisely managed	1996	5.8	39.0	32.2	5.1	19.7
	1993	6.7	39.0	30.5	7.9	15.9
State should regulate private forest	1996	3.5	25.7	47.1	18.7	5.1
	1993	4.3	25.6	41.5	23.8	4.9

the intensity of the disagreement dropped from 23.8 percent who strongly disagreed in 1993 to 18.7 percent in 1996. It is possible to interpret this pattern as evidence of a slight softening of opposition to such regulations, but we should be cautious about suggesting any increased support for regulation.

At this point, we would offer a cautionary tale with some special implications for the MDC. Of the groups we have been discussing, forest owners are the most supportive of the agency's role as manager of State forests and most dependent on them as primary sources of information and advice (Constance and Rikoon 1997a). At the same time, urbanites are most likely to support environmental protection objectives over those related to economic development and to express the least amount of agreement that private forest land is wisely managed. While rural people in general and forest owners in particular oppose State regulation of private forest lands, at least one-half of urbanites express direct support for such action.

In terms of demography and eligible voters in Missouri, urbanites outnumber forest owners, and metropolitan residents outnumber those from non-metropolitan regions. Urban-rural conflicts do not arise over every issue in the state, but at times marked regional differences have appeared in public debates and votes over environmental policies and proposals (e.g., Natural Streams Act) emanating from urban constituencies. In regards to forest sustainability, it is possible that organized urban constituencies could use their votes to initiate or propose legislation that mandates MDC and its forestry division to regulate the private forests. If this scenario was realized, we would face the difficult situation in which an agency may be required to regulate a group of people who are one of its most supportive clienteles and who consider themselves as actively involved in environmental protection (Constance and Rikoon 1997a).

This sort of outcome is not unprecedented. At the national level, the 1985 Farm Bill (Food Security Act), and particularly the cross-compliance provisions included within it, virtually forced the USDA Soil Conservation Service (now Natural Resources Conservation Service) into the role of regulator of farmers participating in Federal farm programs. This new role often put severe strains on close relationships built up over the years between the agency and its farmer-clients (Rikoon and Heffernan 1989). The forest survey data suggest that MDC could be put in a similar situation and, if so, that such a proposition would likely result in both strong resistance on the part of forest owners and negative consequences for agency relationships with this group.

Citizen Knowledge About Forest Land Patterns

Public beliefs about the world, no matter how empirically correct or erroneous, have great impact on their attitudes toward policies and programs affecting forest sustainability. Accurate knowledge about present resource patterns are critical to gaining public support for sustainability projects and for garnering participation in any type of outreach efforts to achieve sustainability objectives. Regretfully, Missouri citizen opinions concerning forest resources and lands in the state must be

interpreted with the proverbial grain of salt because many people appear to have scant knowledge of patterns of private forest land ownership and agency management responsibilities. In fact, there are some huge knowledge gaps, and this situation has changed little over the decade.

Table 11.4 reports the responses to four survey questions intended to evaluate respondent knowledge. Responses to the first question reveal that more than 50 percent of interviewees incorrectly reported that the amount of forest land in the state is decreasing and about another 25 percent claimed the amount had not changed. While more rural respondents correctly identified the increase in forest land in the state, the frequency of correct responses is barely more than 1 out of 9. Forest owners do a bit better, but still less than one-fifth identified an increase in Missouri's forested acres.

While we might reasonably expect knowledge of state land use change to be beyond the experience of most individuals, we could expect better knowledge of general trends of ownership. The second question shows, however, that almost 60 percent of all respondents believed that the government owned more land than private landowners, and only 27 percent of our respondents identified the correct response. The frequency of correct responses in 1996 was five points higher than in 1993, but still rather disappointing given the actual overwhelming percentage (85 percent) of land under private ownership in Missouri. As with the preceding question, rural respondents and forest owners outperformed the norm, but their frequencies were not at a point that would make one comfortable with existing levels of knowledge of forest land ownership or forest tenure.

Table 11.4—*Responses (in percentages) to selected knowledge questions, by respondent groups*

Over the past 20 years, has the amount of forest land in Missouri increased, decreased, or stayed about the same?				
	Increased	Decreased	Same	Don't know
Total sample	10.3	54.6	26.3	8.8
Urban respondents	7.5	56.5	27.9	8.9
Rural respondents	11.3	53.8	24.5	8.8
Forest owner respondents	17.1	49.2	29.5	4.3
Who owns the greatest amount of forest land in the state—private landowners or the government?				
	Private	Government	Same	Don't know
Total sample	27.0	58.7	2.7	11.5
Urban respondents	24.5	61.1	2.3	12.1
Rural respondents	28.3	57.4	2.9	11.4
Forest owner respondents	31.0	56.6	2.7	9.7
Do you believe the Federal or State government owns more forest land in the State of Missouri?				
	Federal	State	Same	Don't know
Total sample	38.0	44.1	1.4	16.5
Urban respondents	38.0	45.2	1.7	15.0
Rural respondents	38.0	43.6	1.3	17.1
Forest owner respondents	39.5	44.6	1.6	14.3
Which State agency has legal responsibility for caring for forest land in Missouri?				
	MDC	MDNR	Other	Don't know
Total sample	45.6	6.6	6.3	43.2
Urban respondents	47.2	6.9	6.5	39.1
Rural respondents	43.3	7.4	4.9	44.4
Forest owner respondents	49.4	7.1	8.0	35.5

Responses to an inquiry as to whether the Federal or State government controlled more forest land in Missouri portray similar, albeit slightly improved, patterns. Between 38 and 40 percent of respondents in each group knew that Federal ownership is larger. As one might expect, knowledge of government ownership of forest land is more prevalent in Ozark regions, although rural versus urban residence made absolutely no overall difference and forest ownership had little influence.

Finally, we asked respondents if they could tell us the name of the State agency with "legal responsibility for caring for forest land in Missouri." Responses to the last question on table 11.4 show that around 45 percent correctly identified MDC as that agency, but more people either "don't know" or chose a variety of other institutions, ranging from the Missouri Department of Natural Resources to the Missouri Department of Agriculture. These figures represent very little change from 1993. Subgroup analysis revealed little variation. Interestingly, urbanites were slightly more likely than respondents living in rural locations to give the correct answer, and forest owners again performed the best of all groups.

In summary of these questions—and other inquiries on citizen knowledge in our survey show similar results—we found that a large percentage of Missourians continue to give incorrect responses to knowledge questions about forest resources in the state. Only a small percentage of citizens knew that the amount of forest land in Missouri was increasing or that private citizens owned more forest land than the government. We feel that the latter category of misperception is the most glaring of the knowledge gaps. Lack of familiarity with present patterns may have an impact on citizen values about sustainability and valued functions of forest lands. Perhaps more significant, however, are the implications of insufficient knowledge on the implementation of strategies to achieve those objectives. We know that there is greater reluctance of many citizens to support or engage in programs that require close cooperation with Federal agencies and that there are increasing citizen anxieties about government acquisition of private lands. Any public project on sustainability must both clear up confusion about land ownership patterns and emphasize domination of forest ownership by private landowners.

CITIZEN TRUST OF THE MISSOURI DEPARTMENT OF CONSERVATION

We want to briefly mention citizen attitudes towards MDC and reflect on the roles the agency might have in implementing any forest sustainability efforts. In summary, our finding in this project, as well as in other research we have conducted (Constance and Rikoon 1993, Raedeke *et al.* 1998), is that MDC has accumulated a wide amount of trust among the state's citizens. No doubt there has been some erosion of this social capital in the past few years, particularly in some regions due to ill-fated programs like Coordinated Resource Management. But it is our opinion that the agency, especially through its field personnel and publications, remains the most visible and viable vehicle for implementing sound and sustainable forestry policies and programs.

Table 11.5 summarizes the general trust of MDC and is one of many survey items dealing with public attitudes toward the agency and its Forestry Division. Between 85 and 90 percent of each group we have been discussing in this essay expressed trust in MDC and, of this number, roughly half rated their degree of trust as high or very high. Similarly the percentage of people extremely skeptical of the agency's judgments hovered only around 10 percent for each group.

Table 11.5—*General ratings (in percentages) of trust in "professional judgment" of MDC, by respondent groups*

		High	Some	Not much	None
Level of trust in MDC	Total	43.2	45.2	2.7	9.4
	Urban	45.6	43.0	2.4	8.7
	Rural	40.9	45.7	3.5	9.6
	Forest owner	45.1	42.0	3.1	10.1

Citizens also perceived MDC as a critical source of information, in fact, a source whose reliability rates higher than apparent actual use of it. Table 11.6 presents respondent group selections of their first and second most used sources of information on conservation issues. MDC is the most often used source among forest owners, the second most frequently consulted source among rural residents, and the third choice among both urban residents and non-forest owners.[2] The last column shows combined respondent ratings of the reliability of various sources. MDC is the top-rated source in terms of reliability, by a significant margin.

These assessments and indicators point to the fact that MDC, including its forestry division, is trusted by Missouri citizens and used extensively for information.[3] We would suggest that MDC is the most appropriate agency to lead any governmental project on forest sustainability. While this recommendation may appear to be little more than preaching for the continuity of existing roles and authorities, it is significant that our data confirm that the agency presently empowered with the state lead in forestry conservation is well received by the general public.

CONCLUSIONS

In terms of efforts to enhance the sustainability of Missouri's forest lands, the major conclusions to be derived from citizen responses to our survey are as follows:

- Respondents as a whole are interested in a holistic conceptualization of sustainability that includes environmental, social, and economic objectives. While as a group they place the highest importance on the ecological and physical dimensions of forests, they also support economic and recreational uses of forest land.
- Respondents believe not only that multiple objectives can be obtained but also that in most cases we should not have to choose between environmental protection and economic objectives. Any proposal that polarizes the issue of sustainability by championing or privileging only a single set of objectives is likely to meet with opposition from citizens who favor multiple objectives.
- When forced to choose between environmental and economic objectives, the majority of respondents will favor protecting the environment. They generally support targeted protection programs rather than sweeping efforts that impose a single set of standards or objectives.

[2]Respondents who selected "Outdoor Magazines" as a source of information may also be designating MDC. The agency's monthly publication, *Missouri Conservationist*, is very popular throughout the state.

[3]Other responses from the survey demonstrated that MDC is the primary choice of contact for forest owners seeking advice on wildlife habitat development or contemplating a timber sale.

Table 11.6—*Respondent use and trust of sources of information on conservation issues in Missouri (in percentages), by respondent group*

	Combined first and second choices of sources of information on Missouri conservation issues				Level of trust*
	Urban group	Rural group	Forest owners	Non-forest owners	Total sample
Newspapers	62.6	49.2	43.4	55.1	2.06
Television	44.1	34.7	26.7	40.1	2.08
Radio	7.4	6.4	5.3	7.0	2.12
Conservation organizations	6.2	8.8	8.4	7.4	1.73
MDC	30.3	41.8	49.4	35.7	1.34
Outdoor magazines	24.1	35.1	37.1	29.9	1.80
Legislators	0.7	0.1	0.5	0.2	2.70

** Rated on a scale from 1=very reliable to 4=not at all reliable*

- Respondents are more satisfied with the management of public forests than the management of privately owned land, although there are some real gaps in their knowledge of who owns which forest lands in the state. Given that the majority feel management on private lands can be improved and that forest lands fulfill many important functions, it appears the citizens of the state would support appropriate programs to improve management of private forests.
- Most respondents express a high degree of support and trust of the Missouri Department of Conservation, but a majority remain unaware of the agency's role in forest management and ownership. Many respondents are unsure of agency authorities and uninformed about patterns of ownership of Missouri's forested areas.
- Any attempt to impose strong regulatory mechanisms to achieve the goals of sustainability would be met with strong opposition and public conflict. Support for regulation of private forest lands is likely to find more support in urban areas than in rural areas or among forest owners across the state.

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Chip Mills and Missouri Forests: A Case Study in Policy Development

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Abstract.—The opening of two high-capacity chip mills in Missouri in the mid-1990s led to a controversy regarding their potential effects on the long-term sustainability of the State's forest resources. In 1998, the governor of Missouri established an Advisory Committee on Chip Mills to address the issue. The committee delivered its final report to the governor in August 2000. This article reviews the context, substantive issues, and outcomes of the committee's work and considers some factors that influenced the process of committee decision making and policy development in response to this issue.

Sustainability is undoubtedly a concept rich in nuances amenable to diverse interpretations. Earlier articles in this volume examined the array of ideas embraced by the ideas of ecological, social, and economic sustainability (Journet and Logan, and Lewis, respectively, this volume), along with a variety of other elements that are important to sustaining forests in Missouri. Another fruitful way to consider a complex idea such as sustainability is by exploring its relevance to a concrete issue that emerges in a real-world setting. In such cases, generalities invariably must be specified, advocates are forced to justify their varying interpretations of the concept in a practical context, and potential consequences of actions derived from such interpretations—e.g., benefits, costs—become more transparent and, in the process, more amenable to evaluation.

One of the most visible issues involving natural resources and the environment in Missouri during the past several years has been the controversy surrounding the potential effects of chip mills on the sustainability of the state's forests and other natural resources. Chip mills process trees and tree parts into tiny wood chips, which are then sent elsewhere to be converted into pulp, and ultimately, into paper products. In the mid-1990s, two high-capacity chip mills set up operations in southeast Missouri's eastern Ozark region, with each mill capable of producing from 250 to 300 thousand tons of wood chips per year utilizing Missouri timber.

Public concerns about potential effects of these mills on Missouri forests prompted Governor Mel Carnahan to appoint an Advisory Committee on Chip Mills in late 1998 to study their economic, social, and environmental impacts. The committee delivered its final report to the Governor on August 31, 2000. Along with an extensive discussion of forests and forestry in Missouri, the report contained 35 recommended actions that might be taken to address the potential effects of chip mills on forest and environmental sustainability in Missouri.

This article presents an overview of the chip mill controversy in Missouri. It begins with a brief review of the establishment and activities of the Governor's Advisory Committee on Chip Mills. Attention then turns to two distinctly different perspectives within which the "chip mill issue" tended to be viewed throughout the course of discussions on the subject, and to the key issues that emerged as the Governor's Committee wrestled with the challenge of completing its task. The committee's recommendations for action, along with varying reactions to them, are then summarized. The final part of the article considers some implications of the process through which the issue evolved for the long-term sustainability of Missouri forests.

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THE CONTROVERSY OVER CHIP MILLS

In the mid-1990s, two high-capacity chip mills[2] set up operations in southeastern Missouri—Willamette Industries, located at Mill Spring in the eastern Ozarks, and Canal Wood Corporation, situated in Scott City on the Mississippi River. By 1998, the expected combined production of hardwood chips by the two mills was anticipated to be in the area of 500,000 tons per year. Each mill was procuring wood from within a radius of approximately 60 miles of its mill site (fig. 12.1). Timberlands account for about three-fifths of the land base within the area around Mill Spring and one-third of the area around Scott City, although not all of the latter area is in Missouri (Governor's Advisory Committee on Chip Mills [GACCM] 2000). Approximately three-quarters of the land area within the source areas of each of the two mills is privately owned. Thus, it is evident that the majority of wood to be procured by the mills would be coming from non-industrial private forest lands.

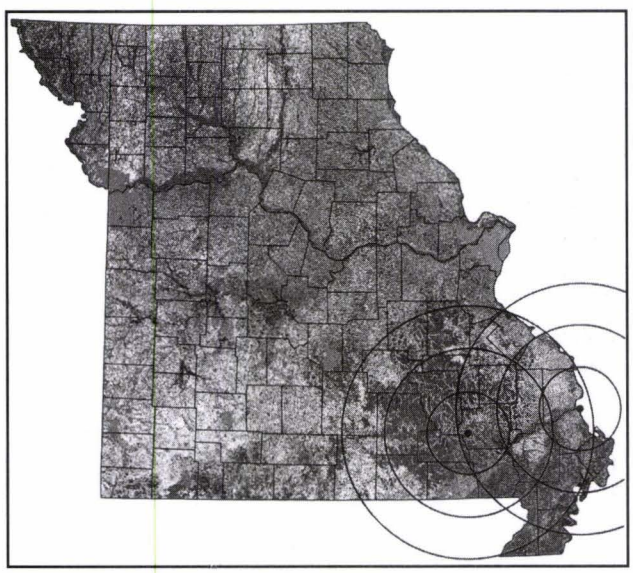

Figure 12.1—*Location of high capacity chip mills and source areas in Missouri.*

Not long after the mills began operating, conservation groups in Missouri, along with some residents in the affected areas, began to voice their concerns about the potential environmental effects of harvesting, particularly clearcutting, in response to demands for wood chips. In September 1998, the above concerns prompted Governor Mel Carnahan to issue an Executive order establishing an advisory committee on chip mills to examine the potential environmental, economic, and social effects of present and future mills on Missouri forests and the citizens of the state. The committee was to be comprised of the following members:

a) Four State departmental directors or their designees: Department of Conservation, Department of Natural Resources, Department of Agriculture, Department of Economic Development;
b) Four State legislators appointed by leadership of the respective chambers: two State senators and two State representatives;
c) Two forest products representatives;
d) Two representatives from citizen conservation groups;
e) One representative from an organization representing private property owners; and
f) A non-industrial private forest landowner.

The committee was to operate on a very modest budget of approximately $25,000 pooled from among the participating agencies.

The Executive order also mandated that the advisory committee undertake a study to identify the impact of chip mills and related harvest practices on the ecological and economic sustainability of Missouri forest resources. The study was to include, but not be limited to, a review of the experiences of other regions of the country with chip mills and related harvesting practices, as well as the economic, social, and environmental impacts of existing and new chip mills in Missouri and neighboring states—including potential environmental impacts related to soil erosion, sedimentation, water quality and watershed protection, habitat loss, biodiversity, and outdoor recreation and tourism. Other required foci of the study included the sustainability of Missouri's forest resources under current timber production levels and the capacity of those resources to sustain

[2]The concept of "high capacity" is a relative one. In some Eastern States, for example, a chip mill described in Missouri as "high capacity" would not be regarded as such. Nonetheless, the two chip mills that set up operations in Missouri provided a stark contrast to the levels of wood processing volumes traditionally seen in the state for this product. To reflect this historical context, the Governor's Advisory Committee defined a **high-capacity chip mill** as a mill that produces more than 150,000 tons of wood chips per year as its principal output.

increased chip mill production levels, as well as a consideration of the impact of chip mills on value-added industries and high-value forest products. Finally, the study was to include an analysis of the long-term profitability of private forests, and it was to address alternative forest resource management and protection standards.

In addressing its mandate, the committee held a series of monthly hearings beginning in November 1998 and extending through July 2000. From November 1998 to August 1999, the committee focused on gathering facts pertinent to the issue. It heard 21 formal presentations during that time from a variety of sources. Each meeting also included an extensive period allotted to public comments. The June 1999 meeting was conducted in conjunction with a field trip to southeast Missouri on which the committee visited several sites exemplifying different kinds and qualities of forest management practices. In September 1999, the committee began its discussion and debate of various potential actions it might take in carrying out its assigned tasks. These discussions continued over the next 6 months. The public comment periods were continued throughout this entire process. In April 2000, votes were taken on approximately 70 different potential options for actions in addressing the chip mill issue. The committee approved the final report at its last meeting on July 31, and the report was submitted to the Governor on August 31, 2000.

The committee obtained input from a variety of individuals and group representatives. These included actors involved in the central process of wood flows from private forest lands to the chip mills—i.e., private forest landowners, loggers, and representatives of the chip mills and other wood products firms. In addition, those indirectly involved in this central process—i.e., professional foresters, natural resource (and other) agency representatives, and scientists and technology transfer professionals—also provided input to the committee. Finally, representatives from groups that had particular economic, environmental, and political interests in the key issues involved were also important sources of information. The committee heard testimony—both in formal presentations and via the public comment process—from all of these actors.

TWO VISIONS OF THE ISSUE

Throughout the committee's discussions and in the extensive testimony it received, two broad perspectives on the potential effects of the chip mills on Missouri forests and other natural resources became apparent. On the one hand, some people viewed chip mills as providing markets for low-quality timber, the rough and rotten trees that sawmills generally do not accept, and thus have usually been left in the woods after harvest, or if harvested, sent to pallet or blocking mills. From a forest management perspective, removal of this lower quality timber from the woods can provide more growing space for higher quality trees in the future. In the process, income is generated for landowners in economically depressed rural areas and some tax revenues are produced as well. The two high-capacity chip mills in Missouri also provide a limited number of jobs for employees (about 40 in all) and for loggers who deliver wood to the mills. In this light, as a source of income for landowners and an economical means for improving forest health by removal of low-quality timber, chip mills have the potential for enhancing both sustainable forests and forest management and the socioeconomic well-being of Missouri Ozark residents.

On the other hand, some individuals and groups were concerned that because almost all trees are potentially convertible to chips (not just mature ones), chip mills can consume wood at a much faster rate than traditional sawmills, and that this in turn would lead to shorter rotations as landowners are tempted to harvest their forests for quick financial gain. Clearcutting would likely be the most preferred method, and its efficiency would not need to be hampered by wood quality considerations. If used properly, clearcutting can be a viable management tool, but, if harvesting is done irresponsibly, it can degrade wildlife habitat and cause soil erosion detrimental to rivers and streams, in addition to its aesthetic repercussions. Moreover, critics of chip mills pointed out that only between 10 and 15 percent of Missouri's 300,000 non-industrial private forest land owners (NIPF) seek or receive any kind of professional forest management guidance when harvesting their timber. This history of poor private forest management in the state, when combined with the incentives for clearcutting provided by the chip mills, led critics of the mills to conclude that

they posed a threat to the long-term sustainability of Missouri forests.

All of the above suggests an intricate relationship between demands for chips generated by the mills and practices conducted on non-industrial private forest lands. Regardless of which of the above perspectives one tended to adopt, one thing became clear to members of the chip mill committee not long after they began their deliberations: the ultimate impacts of high-capacity chip mills on the long-term sustainability of Missouri forests would depend in large part on the quality of forest management the mills encourage (or discourage) by forest landowners in the State. In this light, resolving potential problems posed by chip mills was going to require addressing broader questions related to the management of Missouri's non-industrial private forest lands in general.

Table 12.1—*Key issues that emerged in discussions of the Governor's Advisory Committee on Chip Mills*

- Timber resource availability to support the mills' demand for chips
- Economic impacts of chip mills:
  a) Aggregate
  b) Missouri forest industry: Value-adding wood processors
  c) Recreation and tourism industry
- Environmental impacts of chip mills:
  a) Structure and condition of forest stands
  b) Landowner use of *best management practices*
- Landowner education and information provision: Status and program feasibility
- Logger training: Content and nature of compliance
- Scenario of additional mills locating in state in future: Action required?

CRITICAL ISSUES

During the course of the committee's information gathering activities and subsequent discussions, a number of important issues emerged as integral to any satisfactory resolution of the "chip mill controversy." Table 12.1 summarizes these issues, and a brief overview follows.

Timber resource availability. One important question facing the committee from the outset pertained to whether Missouri's forests and their timber resources would be able to support the increased demand for wood generated by the two chip mills, as well as any other chip mills that might locate in the state in the future. With respect to the mills already operating, it was estimated that if chips were obtained *exclusively* from growing stock in the source areas surrounding the two mills, annual growing-stock harvest would have to increase by 14 percent and 31 percent from current levels for the Mill Spring and Scott City facilities, respectively. At the same time, analysis revealed that the two source areas contained volumes of non-growing stock (i.e., cull material) sufficient to meet estimated chip demands of the two mills for 71 and 23 years, respectively (Shifley 1999a). The degree to which overall forest health could be improved would still, of course, depend largely on the extent to which the large amount of non-growing stock in the two source areas was in fact harvested and ultimately processed by the mills. But in light of the above, the question of whether there was enough wood in the source areas to support the current demand for chips was not a major issue during most of the discussions by the committee. How the current situation would be affected by additional mills locating in the state was another matter, which is addressed briefly below.

Economic issues. An important set of issues discussed by the committee centered on the economic impacts of chip mills in Missouri, both in the aggregate and in terms of the state's wood-based and recreation and tourism industries. Estimating such impacts was a difficult task for the committee, given both its modest level of funding and the fact that the two high-capacity mills had been operating in the state for only a short time. With respect to overall economic impacts, the committee relied on a recent internal report by the Missouri Department of Conservation (MDC) that included a tentative cost-benefit analysis of the potential annual contribution to the state economy of a *300,000* ton chip mill. Based on a variety of assumptions, this study estimated that a chip market in Missouri could yield potential benefits of from $3.2 to $11.1 million, with costs ranging from $1.5 to $10.5 million. Given the uncertainties and methodological problems associated with the estimation of benefits and the hypothetical and inferred nature of cost estimates, it was concluded that the overall result was slightly positive, but

probably "statistically too close to call" (Missouri Department of Conservation 1999).

Another economic issue centered on the possibility that higher quality trees that had previously served as resources for traditional wood products would now be harvested for chips. The question here concerned whether the chip mills would end up processing such quality logs (likely part of bulk volumes associated with clearcuts) that would otherwise yield more economic value—in terms of both products and jobs and income—if they were utilized by value-adding secondary processors to make products such as furniture parts or furniture, finished lumber and millwork, flooring, and paneling. This in turn led to a related concern as to whether the demands generated by the chip mills, and the concurrent wood flows to meet those demands, would adversely affect the survival of any or all of the small secondary wood processing firms in southeast Missouri.

What was actually going through the chip mills was one of the more vexing questions for the Governor's Advisory Committee throughout the course of its discussions. It is central to a number of the concerns involved in the overall chip mill issue. As with many aspects of this issue, the information the committee was able to obtain was mostly anecdotal in nature. Some testimony was presented suggesting that the two chip mills in Missouri were processing a lot of wood for which there was a better use. In a study of chip export mills in Arkansas (a small segment of that state's chip mill industry), Guldin (1999) observed that most of the stands being harvested for chips did have some saw logs in them; some of the chip mills had such contract concerns that they were essentially chipping saw log material, while others were sorting out the saw log material and reselling it to hardwood saw mills at a much higher price. He also noted that the mills were not paying landowners the saw log value of their timber. This study was, however, the only example the committee was able to obtain that provided some direct evidence of landowner harvests and harvesting practices in response to demand for chips. Generalizations were therefore difficult. Ultimately, the committee recommended that legislation be enacted giving a State natural resource agency authority to monitor wood being processed by the mills.

The potential impacts of the chip mills on small firms in the state's lumber and wood products industry would, of course, depend in part on how the above question of what goes through the chip mills played out over time. However, these markets had been volatile for some time, well before the chip mills arrived. Thus, the committee concluded that while the chip mills would likely encourage some competition, which might contribute to driving some of these small firms out of business, at this stage it is unlikely that they would be the sole cause for these firms exiting the industry. The committee recognized, however, that over time a continued use of high-quality wood by the chip mills could intensify the volatility of the secondary wood products market to a greater degree than would have otherwise occurred.

With respect to the potential impacts of chip mills on the State's recreation and tourism industry, the committee had little to go on, even when it sought exemplary analyses from other states. While aggregate data existed documenting tourism as the second largest industry in Missouri and the increase in nature-based or ecotourism, there was little additional information in the form required to make realistic inferences about the impacts of the chip mills and associated harvesting practices on recreation and tourism in the State. As a result, the committee could only recognize that the economic effects of the chip mills on the tourism industry in Missouri would be a direct consequence of the mills' effects on a variety of characteristics that make natural settings in the Ozarks desirable places to visit. This, in turn, would depend on how the frequency, location, and size of clearcuts affected viewsheds around and leading to recreation sites in the Ozarks.

Environmental issues. An equally significant set of issues relative to potential impacts of chip mills in Missouri pertained to the possible environmental effects of harvesting to meet demands for chips on the State's soil and water resources, wildlife habitat and diversity, and overall ecological integrity. Given that such effects would result largely from harvesting practices of NIPF owners, a prime focus of the committee was on how such owners would respond to demands for chips in terms of harvesting practices. One of the most volatile topics throughout the committee's discussions concerned whether landowners should be encouraged to practice good forestry through voluntary incentives or whether some form of

regulatory mechanism requiring ecologically sound forest practices should be instituted.

Given the short time during which the mills had been operating in Missouri, only limited information was available to the committee on forest practices of landowners in response to demands for chips. Testimony at hearings and public comments on draft documents included reports of both good and bad examples of chip harvesting by landowners. In looking to studies in other states, only one was found that attempted to address this question directly, that being the aforementioned small study in Arkansas by Gray and Guldin (1997). These authors constructed a scale of five possible outcomes of harvesting in which the wood harvested was for chip mill consumption. They concluded that the best of the possible outcomes noted above involved the kinds of treatments that chip mills, because of their innate economics, generally don't do or encourage in Arkansas, and that in the large majority of the cases the harvesting for the chip mills was not good forestry (Guldin 1999).

Due to the small scale of the above study and the dearth of other studies directly linking chip mill demands to on-the-ground practices on private lands in response to those demands, the committee deemed it unwise to generalize from this instance to a broader conclusion encompassing all NIPF lands. This did suggest, however, that with respect to the situation in Missouri, and given the history of poor forest management on most private lands even prior to the arrival of the chip mills, simply having an adequate supply of wood in Missouri forests might not be sufficient in itself to lead to sustainable forest management on the state's private forest lands; and that other factors, particularly those linked directly to motivations of landowners to manage their lands, would evidently have to come into play for this to happen.

The above concerns were also part of the committee's discussions on the use of *best management practices* (BMPs) by forest landowners. BMPs may be described as "a combination of practices that . . . [serve as] . . . the most effective, practical means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals" (Tennessee Valley Authority *et al.* 1993). With respect to forest management, BMPs address such elements as streamside management zones, site preparation, woodland grazing, revegetation, truck haul roads, log landings, skid trails, and pre-harvest planning. The question of how to encourage landowner use of BMPs was a major topic of debate for the committee. In turning for guidance to other states that have addressed this problem, the committee considered a variety of approaches to promote the use of BMPs on private lands, ranging from mandatory measures through contingent regulatory mechanisms (i.e., regulations imposed only in the absence of acceptable voluntary usage) and voluntary approaches.

While there was considerable debate and substantial disagreement regarding both the desirability and potential effectiveness of each of these approaches, a majority of the committee ultimately favored voluntary measures with a realistic chance of being successful as preferable to regulatory mechanisms, which were viewed as a means of last resort.

Landowner education and information. The committee recognized that the success of such a voluntary approach to the use of BMPs in Missouri would depend on landowners being educated about proper forest management practices as well as having access to reliable information on markets and prices for forest products and the like. The poor track record in Missouri in terms of landowners seeking professional advice or assistance in harvesting their timber has been noted previously.

The committee discussed a variety of factors relevant to the design and delivery of effective educational programs for private forest landowners. Members agreed that what is important in delivering education and assistance programs is to reach the landowners who are going to make decisions about resource management or to help landowners become more aware of the multiple array of values present in their forest lands. Moreover, forest landowners are not always interested in obtaining information about forest management until they are ready to do something with it. The committee recognized that in Missouri the expense and logistics of putting together such programs had contributed to their reaching only a minuscule portion of forest landowners in the state. Finally, it was generally acknowledged that the financial support necessary for the design and

implementation of the above kinds of programs did not appear to be forthcoming from a State legislature bound by constitutional amendment to return the bulk of budget surpluses to taxpayers as tax refunds.

Given this scenario, the committee agreed that the primary focus of initial landowner education and assistance efforts should be on the source areas for the two high-capacity chip mills. It considered both short-term and longer term perspectives for structuring education and assistance efforts in the source areas. The former would target all NIPF owners in the chip mill source areas to receive a modest packet of information on forest management that may better help them evaluate their options in interpreting and responding to demands for chips by the mills. A longer term perspective targeted landowners with larger tracts (40 acres or more) within the two source areas. It would also allow continued emphasis on the development and delivery of high-quality education and assistance programs to maximize the educational experience of forest landowners. The committee recommended conducting a pilot test of such an approach in the source areas for the State's two high-capacity chip mills.

Logger training. The committee recognized that loggers are a critical part of the landscape of Missouri forestry. As the intermediary between the forest landowner who decides to harvest timber and the sawmill or chip mill that processes the wood, the logger is directly responsible for the environmental impacts of harvesting—whether they be the "traces" of a harvest conducted with the use of BMPs or severe erosion from an improperly conducted clearcut. In addition, the logger frequently assumes a distinct position in the process of *economic* transactions through which wood flows from private forest lands to the mills. With respect to the chip mills, for example, landowners frequently sell their timber directly to loggers, who then deliver the wood to the mill as "gatewood," in the process initiating a separate economic transaction in selling what is now *their* wood to the mill.[3]

It is estimated that there are between 800 and 900 loggers in Missouri (GACCM 2000). The Governor's Advisory Committee devoted considerable attention to whether logger training should be encouraged through mandatory or voluntary means, in addition to concerns about factors such as program content, delivery, and potential effectiveness. As with most aspects of the chip mill issue, the committee tended to look first to the kinds and potential effectiveness of voluntary incentives for logger training. It discussed several forms that logger training programs could take, including registration; licensing as a form of mandatory registration; and certification, which is usually a *voluntary* procedure attesting that a person has attained certain standards (French 1999). As with the issue of landowner education, ultimately the majority of committee members supported a voluntary approach to logger training, opting to allow a program recently established by the state's forest industry time to demonstrate its effectiveness.

The question of future mills. Finally, throughout the course of committee deliberations, the question of what to do about the potential location of high-capacity chip mills in Missouri in addition to the two that were already operating hovered in the background. In considering the capacity of the state's timber resources to support such additional mills, the committee viewed a number of scenarios depicting projected timber utilization levels in response to increased demand for wood chips. The scenarios, constructed by the USDA Forest Service's North Central Research Station (Shifley 1999a, 1999b, 2000) were somewhat conservative in nature, in the sense that a variety of factors resulting in the withdrawal of forest lands from potential availability for chip harvests were included.[4] Some believed these assumptions were *too* conservative, while others thought they correctly incorporated a deliberately cautious approach to the analysis of a question about which the level of uncertainty was inherently high. The committee was evenly divided over the question of whether a moratorium on future chip mills should be imposed, at least

[3]When the chip mills contract directly with the forest landowner for the timber on his or her land, the logger does not assume this intermediate role of wood purchaser, but rather contracts with the mill strictly as a provider of services in harvesting the timber.

[4]These included such considerations as unusable species, riparian and road buffers, steep slopes, and public lands, which were assumed to be dedicated primarily (though not exclusively) to non-timber uses.

until additional information from further studies on the questions could be obtained. Ultimately, a motion to impose a 2-year moratorium was defeated by a vote of 7 to 6.[5]

COMMITTEE DECISIONS

The Governor's Advisory Committee issued 35 recommendations about how to address the chip mill issue in its final report. Only two of the recommendations pertained directly to the chip mills themselves. One called for legislation to establish authority, presumably vested in State natural resource and/or conservation agencies, to identify the kind of timber actually being processed by the two high-capacity chip mills in Missouri. A second proposal recommended that special funding be provided by the Missouri legislature to assess the environmental, economic, and social impacts of chip mills in the Missouri Ozarks.

The other committee recommendations reflected its recognition that the chip mill issue in Missouri will ultimately be played out in terms of the kinds of management practices that landowners employ (or do not employ) in harvesting timber to meet the mills' demand for wood. The committee was hesitant to call for regulation of forest practices on private lands, which some members believed would infringe on private property rights. It did, however, issue one such recommendation that BMPs be required for harvests that remove more than one-half of the timber from any plot of 40 acres or more. The majority of recommendations centered on providing landowners with information and incentives to practice good forestry voluntarily. One such set of incentives would emerge from a comprehensive evaluation of all existing forest landowner education programs in Missouri and involve a high-intensity landowner education effort in the areas surrounding the chip mills. Additional proposed incentives were economic in nature. These included special efforts by State agencies to help small to medium forest products firms that add substantial value to primary timber products to expand or locate in Missouri. Also suggested were reductions in tax liability for forest landowners who use BMPs. These might be instituted by creating a sliding scale of capital gains tax for timber sales, allowing deductions for certain forestry practices as management expenses, or other means.

The committee also called for incentives to encourage voluntary training and certification of loggers in the state, and for the establishment of a professional registry board for licensed foresters to practice in Missouri. Finally, the committee recommended that a Missouri Forest Resource Council be established to foster collaboration and provide an ongoing forum among all groups with an interest in the sustainability of Missouri forests. Such a council, which received broad support at public hearings and committee meetings, would advise the Governor and State, county, and local governments on sustainable forestry policies and practices.

REACTIONS TO COMMITTEE REPORT

The Governor's Advisory Committee on Chip Mills completed its work in about a year-and-a-half on a very modest budget. Given this and the fact that the two high-capacity chip mills had been operating in Missouri for only a short period of time, the committee's strategy was to collect and organize all the existing information it could on chip mills and related forestry practices in Missouri, as well as available information on chip mill experiences in other states. In terms of the scope and factual information on forests and forest management in Missouri, the committee's final report is one of the more comprehensive documents produced in recent years on this subject in the state.

As might be expected given the constraints under which the committee operated, reactions to the recommendations contained in the final report were mixed. The State's forest industry, along with landowners and property rights advocates, were generally satisfied that the report and its recommendations reflected a balanced analysis of a novel and complex situation in Missouri, and that the committee did not "overreact" to the situation by imposing a host of burdensome requirements on landowners, loggers, and wood products firms. On the other hand, the State's environmental

[5]Although the Governor's Advisory Committee declined to recommend a moratorium on new mills, in April 2000, the Missouri Clean Water Commission passed a resolution imposing a 2-year moratorium on stormwater permits for new chip mills in Missouri.

community was bitterly disappointed that the committee did not take stronger actions in addressing the chip mill issue. They believed that the committee's faith in voluntary incentives for landowners and loggers ignored the well-documented tradition of poor forest management in the State. In that regard, they favored stronger regulations on landowner use of best management practices and, at a minimum, a requirement for pre-harvest notification by landowners to inform the MDC Forestry Division of where harvests were occurring in the State, in contrast to a voluntary notification measure adopted by the committee. They also argued that much more attention should have been devoted to regulating the chip mills themselves as industrial entities, and they were most disappointed with the committee's failure to impose a moratorium on future chip mills locating in the State.

The State's two public natural resource agencies had slightly differing perspectives on the outcome of the committee's work, reflecting to a large degree their distinctive missions. As the principal State forestry agency in Missouri, the MDC was for the most part satisfied with the overall outcome, welcoming the opportunity to continue and refine its landowner education programs in light of the information gained from the committee's efforts, without having to incorporate a substantial new regulatory component within their efforts. The Missouri Department of Natural Resources (MDNR) was somewhat less satisfied with the overall outcome of the committee's work than was the MDC. As the State agency through which the Federal Clean Water Act is implemented,the MDNR exercises its enforcement role in ensuring water quality primarily on a complaint-only basis—i.e., after the damage has been done, so to speak. At present the agency has limited means of addressing these kinds of problems from a more preventive posture. The MDNR was hoping to be in a stronger position along those lines as a result of the committee's work, but its position would remain essentially the same even if all the committee's recommendations became reality.

KEY FACTORS IN POLICY DEVELOPMENT

At this writing, about a year-and-a-half has passed since the committee issued its report in August 2000. To date, only limited activity has occurred from a policy perspective, a consequence of several political and economic events that have transpired since the committee's report was issued. On the one hand, state and national elections took up much of the political attention in Missouri for the rest of 2000, and given the election's national repercussions, into early 2001. The tragic death of Governor Mel Carnahan in a plane crash in October 2000, several weeks before the November election in which he was the Democratic candidate for the U.S. Senate, while not likely to have substantially affected subsequent actions relevant to the chip mill issue (given that Carnahan was leaving the Governor's Office at the end of the year), nonetheless absorbed much of the political consciousness of Missourians during this period as well. During the 2001 State legislative session, two bills were introduced on topics discussed during the chip mill hearings, although neither was ultimately enacted. The first called for mandatory licensing of foresters in Missouri, a measure that had received widespread support during the committee hearings, including that of the State chapter of the Society of American Foresters. The second bill proposed cost share incentive programs to promote sustainable forestry and soil erosion control on private lands. For landowners to be eligible for cost share assistance, they would have to carry out forestry activities using BMPs.

At the same time, the economic landscape for the state's two chip mills has shifted substantially from the period during which the committee addressed the issue. In early 2001, Willamette Industries transferred its procurement forester for the Mill Springs facility to Tennessee, in the process limiting its intake at the mill exclusively to gatewood (i.e., that delivered by independent loggers). In general, the overall level of wood being processed by the Mill Spring facility is substantially less than at its earlier peak; as of late 2001, the mill was operating at about 20 percent of capacity. Nationally, moreover, Willamette became engulfed in fighting off a hostile takeover bid by Weyerhaeuser Corporation, to which it ultimately agreed in the first quarter of 2002. At present, therefore, the Mill Spring chip mill is owned by Weyerhaeuser. The Scott City chip mill operated by Canal Wood Corporation had exported all its chips to Japan, which continues to be mired in an extended economic slump. In the first quarter of 2001, Canal shut down operations at its Scott City mill, although it still owns the facility and has not dismantled it.

Meanwhile, the moratorium on the issuance of new stormwater permits for chip mills expired in April 2002, although at this time there appears to be relatively little interest on the part of major pulp and paper concerns to establish such facilities in Missouri in the near future. At present, therefore, the chip mill issue is not as volatile as it was during the time prior to and during the committee's existence. Nonetheless, given that many of the concerns raised during the process are as yet unresolved, substantial interest remains in the implications of the chip mill experience for the long-term sustainability of forests and forestry in Missouri. A number of groups are continuing to assess the array of issues that surfaced during the chip mill debate, as exemplified by a statement issued in May 2001 by the Conservation Federation of Missouri, which requested that the Missouri General Assembly and relevant State and Federal natural resource agencies use the chip mill report and its recommendations "as a source document and as a blueprint for enacting future legislation, studies and those actions needed to sustain Missouri's forests, its associated resources and the needs of our society" (Conservation Federation of Missouri 2001).

In the meantime, a bill regulating the establishment of new chip mills in Missouri was introduced in the 2002 legislative session. The Chip Mill Permit and Accountability Act (HB2040) would institute a comprehensive permit structure and a resource impact analysis by the State for all new chip mills wishing to operate in Missouri. The State House Environment and Energy Committee heard testimony on the bill in early April, although ultimately no action was taken during the current legislative session.

In light of the above, it is worthwhile to briefly consider some lessons learned from the chip mill experience thus far in Missouri. Figure 12.2 presents a sketch relating several topics that merit attention when considering the implications of the chip mill debate for the sustainability of Missouri forests and other natural resources. Reflected therein is the fact that the central dynamic underlying the decisionmaking process of the chip mill committee—which included factors such as relationships among committee members, the manner in which issues were discussed, and how and when decisions were made—was itself influenced by a variety of additional factors such as the ideological orientations of committee members and stakeholders, the organizational cultures of the two major State natural resource agencies involved, the information base available for committee decisions, and the broader institutional context within which these kinds of problems/situations have traditionally been addressed in the State of Missouri. All of these factors undoubtedly influenced the outcomes of the committee's activities as reflected in the set of recommendations and other information included in its final report.

When the committee held its first meeting in November 1998, it was expected that the group would issue its final report to the Governor in November of the next year, a month prior to the December 1, 1999, expiration date for the committee as specified in the Governor's original order (Executive Order 98-16). From January through August, the committee focused on gathering information pertinent to the issue, listening to 21 formal presentations from a variety of sources. Each meeting also included an extensive period allotted to public comments. The June meeting was conducted in conjunction with a field trip to southeast Missouri during which committee members visited several sites exemplifying different kinds and qualities of forest management practices. In September, the group began its discussions of potential actions it might take in carrying out its assigned tasks. Initially there was a sense of concern among committee members that they may have devoted too much time to gathering information relative to that which remained for making decisions. In addition, several members warned that there would not be adequate time for public review of a draft document prior to submission of the final report to the Governor at the beginning of November. To address this latter concern, the committee requested and received an extension of its expiration date to February 1, 2000 (Executive Order 99-11). While not alleviating the time constraint on decisionmaking, this did provide the committee with a small amount of breathing room for refining its final decisions based on input received from the public review. Nonetheless, in light of time limitations, the committee decided in September to issue its final report without taking votes on specific courses of action, but rather exclusively in narrative form.

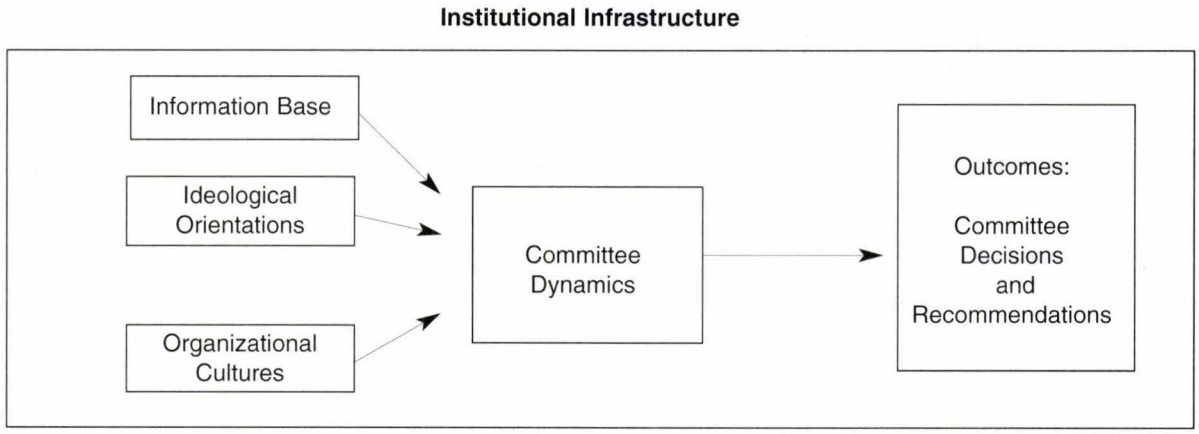

Figure 12.2—*Important factors in the decisionmaking process of the chip mill committee.*

During the public review period in December 1999, however, it was revealed that the MDC had compiled an "Internal Report on the Chip Mill Issue" dated December 1998, which had not been made available to the chip mill committee during its deliberations (Leonard 2000). This led the Governor to issue a third Executive Order mandating that the committee continue its operations "as long as it would take" to examine, solicit public input on, and incorporate the MDC internal report into its decisionmaking responsibilities (Executive Order 00-01). As a result, the committee devoted two meetings in the first quarter of 2000 to discussing and receiving public comments on the MDC report. At the same time, given the extended time now available for completing its task, the committee decided that it *would* take formal votes in the process of issuing its final recommendations, and it did so at its meeting in April 2000. At that time, votes were taken on approximately 70 different potential actions for addressing the chip mill issue. After subsequent consolidation of overlapping measures and refinements of others, in July the committee approved the 35 recommendations ultimately submitted to the Governor in its final report.

Committee dynamics and ideological orientations. There is a certain dynamic to any decisionmaking group, such as the Governor's Advisory Committee on Chip Mills, that is created as an *ad hoc* response to a particular issue and charged with examining that issue's origins, dimensions, and implications and making policy recommendations. Any such group must initially define its identity, agree on its goals, and become comfortable with the procedures through which it would address its task. This dynamic began to take shape throughout the first 8 months of committee hearings (January to August 1999), during which the committee focused primarily on gathering information from interested parties—State natural resource agencies, academics and researchers, forest industry representatives, environmental groups, and so on—invited to present their perspectives on the issue.

As described earlier, both committee members and interested parties tended to view the chip mill issue through one of two distinct perspectives, each of which led to a different conclusion regarding the likely impacts of the mills on the long-term sustainability of Missouri forests. From one perspective, chip mills, by providing markets for low-grade wood previously ignored or left onsite during timber harvests, could lead to healthier forests in the long run by encouraging the removal of cull material and in the process opening up the forest for quality trees to grow. From the opposing perspective, while this might be true, given landowners' past history of not soliciting professional advice on proper harvesting techniques and the fact that funds necessary for truly effective landowner education efforts were not likely to be forthcoming, a more likely scenario would be that the chip mills would encourage landowners to clearcut their forests for short-term profits, which in turn would likely have adverse effects on forest sustainability. Given the above visions of the issue, it was not entirely surprising to find that the hearings and overall course of events described above were characterized by an ebb and flow of varying expressions of these two perspectives, accompanied by the formation of

small coalitions of committee members who strongly favored one or the other view, and others who leaned in one direction or another. It would be difficult to say that any of the committee members—some of whom, it may be recalled, were appointed as representatives of groups with set views on the issue—entered the process with an entirely neutral perspective on the subject.

As the hearings began in earnest in January 1999, all members of the committee agreed that a key goal of their efforts was to contribute to the long-term sustainability of Missouri forests. Moreover, as they began to gather more information on the subject, members also came to recognize that the chip mill issue did not simply begin and end with the status and operation of the mills themselves, but rather encompassed all of forestry in Missouri, as reflected especially in the forest practices conducted by the more than 300,000 non-industrial private landowners in the state from whom the mills would receive the bulk of their timber inputs.

From that point on, however, it became evident that the views of committee members on the issue tended to be consistent with one of the two distinct visions described above; that their views (and the visions themselves) tended to reflect an underlying ideological orientation towards, among other things, the appropriate role of public (i.e., governmental) vs. private sector mechanisms for addressing the problem; and that together these overall views were shaping the coalitions among committee members that would ultimately assert themselves when decisions were actually made. Two members, for example, clearly believed that the chip mills could be a positive force for forest sustainability and that the public role should be one of providing positive incentives for landowners and industry as opposed to any form of regulatory action. Two other members took the opposite perspective, being skeptical that the chip mills would encourage sustainable forestry and therefore much more receptive to the potential role of some kind of regulatory incentive(s) to encourage sound forest management in the state. Two legislators leaned towards the former view, while one clearly favored the latter. (It should be noted that one of the legislator appointees did not attend the majority of meetings or participate in the voting process in April 2000, in effect reducing the number of committee members who actively participated in the process from 14 to 13.)

Three of the six remaining committee members were State agency representatives. Two leaned toward the view that chip mills could pose a problem regarding forest sustainability and that a wide range of government actions, including regulatory incentives, should remain open as possible options; the third was reluctant to express a position on either of the above. The remaining three committee members tended to have mixed feelings regarding the potential effects of chip mills on forest sustainability and the implications of this for the kinds of incentives (voluntary vs. regulatory) that would be required. One member, for example, had strong concerns about the impacts of the mills on forest sustainability and, in particular, on the overall health of the State's forest products industry, while remaining ambivalent on the most effective kind of public incentives for landowners. Another member clearly believed that the mills could have a positive affect on forest sustainability, leaning toward voluntary, as opposed to regulatory, public incentives; the third, while skeptical of any regulatory measures as incentives for landowners, tended to lean slightly to the view that chip mills would not necessarily be good for Missouri forests or forestry. What emerged from the above as discussions regarding options for committee actions began in earnest in September 1999 was a scenario in which nine committee members appeared to have relatively set positions on the issue, and thus the outcomes of committee votes would likely hinge to a large degree on those of the remaining three members as mentioned above, along with one of the four State agency representatives.

This dynamic was indeed played out both during discussions prior to voting and in April 2000, when the committee voted on 70 possible options for potential adoption as its final recommendations. To begin to appreciate why this process was so, it is helpful to recognize that the two visions of the issue described above actually reflect more comprehensive ideological orientations with which those perspectives are consistent. An *ideology* may be defined as a set of ideas, beliefs, and attitudes, consciously or unconsciously held, that reflects or shapes understandings or misconceptions of the social and political world (Routledge 2000: 381). Ideologies serve to justify and endorse

certain kinds of collective action aimed at preserving or changing political practices and institutions. For present purposes, such ideologies may be viewed as the political worldviews that committee members (and all interested parties) brought with them to the chip mill debate and within which they tended to interpret the many facets of the issue.

It is worthwhile to briefly consider how the two distinct visions of the chip mill issue reflect the alignment of elements within these distinctive ideological orientations toward social and political life. Those who took a more favorable view of the mills in terms of their potential for enhancing the sustainability of Missouri forests tended strongly to do so within the context of a broader ideological orientation towards individualism; those who believed that the mills would have negative implications for forest sustainability tended to appeal to elements of a communitarian political philosophy in justifying their positions. These orientations had a major influence on committee dynamics and the way the committee ultimately addressed its task. Several elements (foci) toward which each ideological perspective tends to take a distinctly different position are presented in table 12.2.

These ideological orientations essentially reflect visions of what a society should be like—i.e., the nature of democracy, the scope of individual freedom, the role of government, and the like. Each orientation takes certain consistent positions on numerous foci or elements of concern relative to political life. While any individual's perspective may vary according to one or another of the elements that together define his/her ideological orientation, the elements do tend to be consistent with one another and, therefore, to lead the person to endorse many (if not all) of the elements within a particular orientation.

Individualism has many meanings. It reflects the dominant American tradition in our day of "endorsing the highest possible degree of individual liberty and self-development in political, religious, social, and economic affairs" (McClay 2001: 395). There are, however, many strands of political thought in which the individual is paramount but that lead to widely divergent interpretations of desired political action—from liberalism to libertarianism. In this regard, the strand of individualism endorsed to varying degrees by committee members who took a positive perspective on the potential impacts of chip mills on forest sustainability in Missouri was clearly of the libertarian, as opposed to liberal, variety. From this perspective, the inherent worth of the individual is anchored in the private sphere of society in which each individual is free to choose his or her actions in pursuit of personal goals. The principal role of government in such a setting

Table 12.2—*Components of ideological orientations underlying two general perspectives on the relationship of chip mills to the sustainability of Missouri forests*

Perceived effects of chip mills on forest sustainability:	Positive	Negative
Ideological orientation:	Individualistic	Communitarian
Focus of concern:		
Sphere of life	Private	Public
Locus of action	Individual	Society (Group)
Goal orientation	Personal achievement	Public interest
Focus of moral claims	Rights	Responsibilities
Role of government	Less activist	More activist
Status of market	Relatively unconstrained	Somewhat constrained
Motivational force	Positive incentives	Regulatory incentives
The *common good*	Adjusts to patterns of individual preferences	Provides standard for evaluating individual preferences

is limited to providing the basic guarantees (such as security, protection of rights, and enforcement of contracts) necessary for individuals to pursue their interests in an unconstrained manner. At the same time, libertarian individualists tend to place more faith in the ability of a relatively unconstrained market, as an institution grounded in the interaction of willing buyers and sellers, to resolve social problems whenever possible, in preference to government interventions that may constrain market processes. Two tenets of libertarian individualism particularly relevant to the chip mill debates are the guarantees of individual liberties as expressed in a set of rights to be respected regarding all individuals, and the idea that incentives to motivate individuals to act in the public interest should take the primary form of positive, voluntary measures in contrast to constraints that restrict an individual's range of choices in some way.

McClay (2001: 396) points out that if anything, "the language of individual rights, and the tendency to regard individual persons as self-contained, contract-making, utility-maximizing, and values-creating actors, who accept only those duties and obligations they elect to accept, grew steadily more powerful and pervasive in the latter half of the 20th century." He continues by noting that "the recourse to individual rights, whether expressed as legal rights, voting rights, expressive rights, reproductive rights, sexual rights, membership rights, or consumer rights, has become the nearly invincible trump card in most debates regarding public policy." With respect to the chip mill issue, we may add another basic right to the above list: that associated with the ownership of private property. The "sanctity" of property rights reflects the fundamental belief that people are entitled to their holdings (if justly acquired), where "entitlement" means having an absolute right to freely dispose of them as one sees fit, as long as this does not involve force or fraud (Nozick 1974).

A communitarian ideological perspective focuses in particular on collective efforts required to achieve group, as opposed to individual, goals. Although not ignoring the inherent value of individuals, such a perspective emphasizes that the values of community and individuality, far from being in opposition, are mutually supporting and mutually sustaining—that is, the individual best defines himself or herself as a member of a community and the latter is both essential to that process and is enriched because of it. As a key locus of collective decisions, government can and should not only provide security for citizens and safeguard individual rights, but also, via active citizen participation as the vehicle for collective action, take certain active steps to promote the well-being of society. In certain circumstances, this may require intervention in the market to counteract dynamics that lead to socially undesirable effects, e.g., excessively skewed income distribution, environmental degradation, and so on. Occasionally this may require that collective constraints be imposed on individual behaviors, i.e., regulatory as opposed to exclusively voluntary incentives for individual action. While respecting individual rights, a communitarian perspective tends to emphasize that all rights entail corresponding responsibilities—at a minimum the obligation to respect others holding those rights—and that these need to be spelled out and addressed as thoroughly as the rights themselves. From this perspective, the common good, far from being simply the aggregate adjustment to the sum of individual preferences in a society, is rather a collectively derived set of ideas and values that supplies a substantive standard for evaluating individual preferences and may at times constrain the latter if they deviate substantially from communal values. At the root of a communitarian philosophy is the belief that public life is a realm that needs to draw upon communally established values and principles to produce a workable consensus for governing.

In light of the above, we may say that libertarian and communitarian political philosophies provided the basis from which the elements of two broad ideological orientations of participants in the chip mill debates were drawn, and to which participants appealed in justifying each of the two distinct visions of the issue regarding the potential impacts of chip mills on forest sustainability in Missouri. Those who took a generally positive perspective of the likely impacts of the mills on forest sustainability tended to do so through the ideological lens of libertarian individualism; those who took the opposite perspective tended to reject the former vision precisely because they did not see such a scenario unfolding unless it was accompanied by stronger collective action justified in accordance with communitarian principles.

This in turn directly affected both the pattern and substance of debates by the committee and the subsequent votes taken on potential policy recommendations. In particular, the "faultline" carved out by these two visions inevitably seemed to surface whenever the question of voluntary vs. regulatory incentives for landowners to practice good forestry assumed the spotlight. The pattern of discussion might best be summarized by an excerpt from the chip mill report itself. Declaring the intention of the committee to favor educational measures, technical assistance, and positive incentives (e.g., cost shares, tax credits) in preference to regulatory measures whenever the former seemed likely to be effective, the report noted:

> In discussions of the 'chip mill issue' by the Governor's Advisory Committee, the question of respect for private property rights invariably surfaced (at least implicitly) whenever the possibility of instituting any kind of regulatory measure affecting the actions of private forest landowners was raised. . . . The regulatory option in turn invariably surfaces in response to the question "What if the positive incentives and related approaches don't work, either because landowners are not sufficiently motivated by them or there are simply not enough financial resources available to fund an effective educational and/or incentive program?" When the regulatory option is then raised, the above kinds of questions related to property are often concurrently raised as well (explicitly or implicitly). Frequently discussions reach an impasse at that point, and this tended to be the case throughout the series of meetings held by the Committee (Governor's Advisory Committee on Chip Mills 2000: 112).

In particular, the regulatory option surfaced regarding options related to landowner use of BMPs, harvest notification, and logger training. Thus, for example, one suggested option involved establishing a requirement that a landowner file a notification of intent to harvest timber for sale. Such a harvest notification system, it was suggested, could be administered by local MDC forestry district offices and would provide a mechanism whereby the agency could ensure that all landowners contemplating timber harvesting received information on sound forest management in a timely manner. Discussion of the pros and cons of such an option eventually reached a point where one or more members suggested that this could be an infringement of landowner property rights. This claim was, in turn, supported by a logic of argumentation succinctly summarized by Kymlicka (1990: 152).

> Libertarianism gains much of its popularity from a kind of 'slippery-slope' argument which draws attention to the ever-increasing costs of trying to meet the principle of equalizing circumstances. . . . [L]ibertarians say the attempt to implement that principle inevitably leads in practice down a slippery slope to oppressive social intervention, centralized planning, and even human engineering . . . . where the principle of respect for choices gets swallowed up by the requirement to equalize circumstances.

In this case such a logic was expressed via the hypothetical scenario that if one, even mildly intrusive requirement for harvest notification were imposed on landowners, it would not be long before more stringent, intrusive regulations would be adopted, and so on, leading to dreadful social results. A principal consequence of the above pattern of argumentation was that, as noted above in the committee report, at that point the discussion of the subject invariably ended. That is to say, at the very point when the heart of the issue was reached, and which at a minimum begged for consideration of a series of overarching and re-orienting questions such as 'How did we get to this point?' 'What do we mean by balancing rights and responsibilities?' 'Is there a way to accommodate concerns of those on both sides of this issue;' and so on, the discussion terminated completely.

As indicated in the above excerpt from the committee report, this pattern occurred on several occasions throughout the course of committee discussions, exemplifying the power of ideological orientations to exert their (in this case, negative) influence on the dynamics of committee interactions. The point here is not necessarily that such orientations, or potential courses of action derived from them, are necessarily wrong—they may not be. Rather, the point is that no such perspective or other argumentative mechanism should short-circuit

the process of deliberation through which the committee itself must travel to effectively come to terms with the issues involved and, perhaps, even to arrive at some agreement on how to interpret and subsequently act on those issues.

Existing information base. In addition to the influence of ideological orientations on the dynamics of committee interactions, several other factors also affected the pattern and substance of the committee's deliberative process (fig. 12.2). As part of its mandate, the committee was expected to compile as much existing information on the issue as it could in the time allotted as a basis for discussions and decisions. An important part of such information was that provided in the formal presentations during the first 8 months of committee hearings. The committee also allocated a modest amount of funds for a bibliography on forest practices and a set of scenarios projecting impacts on future timber volume and removals in Ozark forests in response to a range of potential levels of wood demand emanating from the two chip mills. These were competently provided by members of the state's forestry research community.

Nonetheless, given the wide range of topics for the committee to address as specified in the original Executive order, it is clear that the status of the *existing information base* on Ozark forests and the people who live there made the committee's task all the more formidable. Perhaps the most well established and comprehensive database from which the committee could draw information was that regarding the timber resource in the Missouri Ozarks. The Forest Inventory and Analysis (FIA) unit of the USDA Forest Service has been systematically compiling such data on growing stock, growth, removals, and other resource characteristics, for many years; and even though the most recent inventory results would not be available until after 2000, the 1989 statewide inventory and subsequent updates did provide a sound basis from which inferences could be drawn regarding past and future trends affecting the state's timber resource.

This did not mean, however, that the committee had all the information it needed to know about the state's timber resources and harvesting activities. For although such aggregate FIA data are a source of valuable information on timber growth, removals, and other parameters at the county level and above, they do not reveal exactly where timber is being harvested within a given county. This makes it very difficult to ascertain exactly where timber is being harvested in the short run (i.e., between the recently established 5-year periods encompassing a full FIA statewide inventory cycle). Since the chip mills had only been operating in the state for a few years when the hearings began, the committee was unable to assemble a clear picture of the relationship between wood demands by the mills thus far and the actual location of timber harvests that supplied the mills. This, in turn, precluded any overall assessment of positive or negative *effects* of such harvests on short-term forest stability.

As noted above, one option that was suggested involved establishing a requirement that a landowner file a notification of intent to harvest timber for sale. Proponents of this measure argued that in addition to being a vehicle for the delivery of information on sustainable forestry practices to landowners (as described earlier), such a system would provide information on where timber was being harvested in the short run. It was also argued that a harvest notification process could begin to address another problem relative to the overall information base for committee decisions, i.e., that related to the status of *ecological* information on Missouri forests. This was especially important to those committee members and groups who were skeptical that the chip mills would be good for forest sustainability in Missouri. For while questions related to the timber resource could be addressed by reference to concrete historical data depicting such things as trends in growth and removals in the Ozarks, information describing the same area in terms of broader ecological characteristics that some feared might be "at risk" due to activities of the chip mills simply did not exist in the detail required to construct a comprehensive ecological profile for the Ozark landscape. For the most part, the committee had to learn about the critical components of the Ozark ecosystems on a piecemeal basis—e.g., water quality of Ozark streams, species of conservation concern, or descriptions of ecological processes that might be affected by harvesting in response to the mills. This highlighted the need to improve the existing ecological information base for forests and natural resources in Missouri. An important

step in that process will occur with the completion of an *Atlas of Missouri Ecoregions* (Nigh and Schroeder 2002). This will provide a com-prehensive classification of the Missouri landscape according to the national hierarchy of ecological units.

With respect to the option of harvest notification, it was pointed out that not knowing *where* harvesting occurs until long after the fact also severely complicates the task of assembling information for landscape-level assessments of resource availability and ecological integrity; proponents argued that the notification process would address that difficulty as well. In discussions among committee members, most proponents of requiring harvest notification were impressed with its efficiency, noting that it could conceivably do at least three things at once at a relatively modest cost of administration, and that it was the least intrusive way to ensure that land-owners would be both informed about proper forestry practices and adequately motivated to contribute information that would lead to a better understanding of the Ozark landscape from the perspective of both timber management and ecological integrity. Opponents of the mandatory notification option, however, tended to view it as an unwarranted infringement on landowner privacy and decisionmaking. They also voiced the concern that it could be a vehicle for imposition of more stringent regulations in the future, one of several examples of the slippery slope alluded to earlier. Ultimately, the committee decided to phrase its recommendation regarding harvest notification not as a requirement, but rather as a voluntary measure that landowners might wish to follow. The voluntary notification recommendation passed by a vote of 6 to 3 (five members were absent for this vote).

Finally, the information upon which the committee had to rely for gaining an understanding of the economic and social characteristics of people living in the Missouri Ozarks was extensive, but often not in the form most amenable to the kinds of decisions the committee had to make in addressing its tasks. While some economic information on particular outputs (e.g., timber prices) was readily available, that on others (e.g., recreation and tourism impacts) was difficult to extract from existing sources. The committee certainly did not have the resources to construct an information base that included, for example, the structure of the wood-based industry in the Ozarks, and the relative economic viability of timber- or tourism-based localities. In addition, there is a need to more effectively integrate the wealth of county-level data collected by the U.S. Bureau of the Census within a regional framework for better applicability to broader ecological and socioeconomic concerns that are manifest in specific issues such as the chip mill controversy. Information on landowner attitudes and motivations for forest land ownership, patterns of land tenure, and other matters was also limited and outdated. In this latter regard, a cooperative project initiated by the Department of Forestry at the University of Missouri-Columbia in six counties of the Missouri eastern Ozarks represents an important step in addressing this need. In short, strengthening the information base relative to the people who live and work in the Ozarks, own land in Ozark counties but live elsewhere, or simply visit and value the State's forested areas must go hand in hand with any effort to provide policymakers with the kind of information they need to make effective decisions about the state's timber and ecological resources.

Organizational cultures. Another factor that influenced the dynamics of the committee's decisionmaking process reflected the distinctive responsibilities of the two principal State natural resource agencies in Missouri—the MDC and the MDNR. As noted earlier, as the principal State forestry agency, the MDC would naturally be expected to be at the forefront of the discussions on a forestry issue throughout the course of the committee debates. But the agency was forced to assume a more passive posture due to a number of circumstances. As the hearings began, there had been some criticism of the agency—in particular, its Forestry Division—by opponents of the mills who claimed that it had "encouraged" the mills to locate in the state in the first place and that it should have anticipated possible problems that might arise from their operations. However, while the MDC had provided the chip mills with information on the state's timber resources, such information is public in nature and available to anyone who requests it. It is fair to say that the majority (but not all) of the MDC's forestry professionals tended to take a positive view towards the potential impacts of the mills on long-term forest sustainability in Missouri (i.e., the first of the two "visions of the issue" described

earlier). This in itself is not entirely surprising, however, given that in such a scenario good forestry is being practiced and, as a result, forest health is improving, and this to a large degree is what the forestry profession is all about. Nonetheless, as the hearings began, many of the groups who adopted the opposing vision of the issue entered the process suspicious of the agency's motives relative to the outcome of the committee's work.

Such a reservoir of feeling may have eventually dissipated to some extent had it not been for subsequent events that, for many, only served to strengthen the above perception. When the committee was established, the Governor appointed the directors of the MDC and MDNR (or their representatives) to serve as co-chairs. The MDNR director served on the panel, but given the nature of the issue, the MDC director appointed the head of the agency's Forestry Division, who was also the Missouri State Forester, to assume the position of MDC co-chair. In August 1999, 8 months into the process, the MDC co-chair resigned his position as head of the Forestry Division and took a position with Willamette Industries in South Carolina. Willamette, it may be recalled, owned the chip mill facility at Mill Spring. Although he was certainly free to do so, it also was hardly surprising that those with a skeptical vision of the potential impacts of the chip mills saw this as a confirmation of their previous suspicions that the MDC was "in cahoots with the chip mills" on this issue. When MDC's internal report on the chip mill issue surfaced in December 1999, a full year after it had been prepared, those opposed to the mills regarded their perspective on this aspect of the issue as entirely confirmed.

In terms of direct effects of these events on the overall process through which the committee addressed its task, it can be said that of the three aspects mentioned above, the MDC internal report was by far the most significant. On the one hand, as co-chair of the committee through August 1999, the State Forester exercised his responsibilities in what appeared to be an unbiased and judicious manner. On the other hand, there is no question that the MDC's internal report contained important information that should have been (and ultimately was) incorporated into the committee's final report. With respect to the overall dynamic of committee interactions, however, the net effect of all of the above was that the principal State forestry agency was precluded from taking an active leadership role that would have been entirely appropriate under such circumstances, given the nature of the issue. "Leadership" in the above sense is not meant to imply a dictating of the agenda or deliberate steering of discussions in certain directions. Rather, as the locus of State-level professional expertise on the subject, it is meant to suggest a presence in which participants and attendees could be confident that the agency would enthusiastically provide extensive background on and interpretations of the many facets of what is undoubtedly a complex and multifaceted issue involving Missouri's natural landscape.

In discussing reactions to the committee's report, it was noted that the distinctive missions of the two State natural resource agencies inevitably affected their perspectives on the nature of the issue and the outcomes of committee decisions. With some exceptions, professionals in each agency tended to adopt different perspectives on the issue as reflected in the two visions described earlier. This explains, among other things, why the MDC could be seen as "more satisfied" and the MDNR "less satisfied" with the outcomes of committee votes. Directly reflecting their respective missions, the MDC tended to approach the issue as primarily a forest management problem that could be resolved through implementation of sound forestry practices, while the MDNR was more concerned about the potential problem of adverse environmental effects caused by landowners with poor track records in forest management. This is not at all to suggest that MDC is not concerned about environmental damage or that the MDNR is uninterested in forest management. Rather, it simply highlights the fact that agency missions by their very nature tend to focus the attention of their members in certain directions.

Moreover, the history, missions, and distinctive governance of the two agencies—i.e., a constitutionally established bipartisan conservation commission for the MDC vs. a gubernatorially appointed director for the MDNR—have contributed to the evolution over the years of distinctly different organizational cultures within which their missions are pursued. Briefly, it is undoubtedly true that since its creation in 1937 the MDC has been the major locus of forestry-related management and

expertise about State-administered public and private lands in Missouri (this excludes, of course, the important role of the USDA Forest Service with respect to Missouri's national forest lands), and its professional foresters have pursued their programs in relative isolation from political influence. The variety of responsibilities entrusted to the MDNR, established in 1973, include its role as the principal agency for the control of environmental pollution in Missouri, including the non-point variety that may result from improper forest management practices, and the agency with its politically appointed director has been somewhat more responsive to changing citizen environmental concerns over the years. Given these distinctive missions and organizational cultures, varying perspectives on the more or less prominent features of natural resource-related issues are virtually ensured.

At the same time, it is fair to say that the direction of natural resource management has in recent years taken a distinct turn for the better in adopting an ecological perspective toward land and resource management. It is difficult (and undesirable) to separate water quality problems from forest problems when both are dimensions of the same ecological matrix. From the perspective of the MDNR, its authority to respond to water quality problems primarily on a complaint-only, after-the-fact basis conveys an image more akin to a fire station responding to alarms than an agency with a positive role in prevention and education. With 14 million acres of forest land in Missouri, it seems unfortunate that the State's major agency concerned with water quality is in many respects a "stranger to forestry," particularly given the proactive potential for many aspects of forest management to add the beneficial effects of prevention to the more restrictive task of enforcement that defines an important part of the MDNR's mission. One lesson to be learned from the chip mill experience is that a renewed and enhanced level of cooperation between the two agencies can benefit not only each other but all Missourians. For despite their distinctive missions and vastly differing organizational histories, both the MDC and the MDNR are comprised of resource professionals sincerely dedicated to the long-term sustainability of Missouri forests and other natural resources. While pleas for enhanced cooperation are no doubt routine in articles such as this, this is more relevant than ever in a time when concern for and demands upon Missouri's forests and other ecological resources continue to evolve and accelerate.

Institutional infrastructure. The above reference to a primarily reactive posture is actually an appropriate characterization of the entire course of events that have constituted the chip mill issue in Missouri. The Governor's Advisory Committee was established in reaction to events that had been occurring over several years and, upon its creation, was asked to address an extremely complex issue in a short period of time with a very modest budget. Given these severe constraints and despite the inevitable disagreements about specific conclusions and recommendations, the committee completed a difficult task in an admirable fashion. At the same time, and focusing here on the State's forest resources, it would be helpful if issues of this nature could be addressed in a more systematic and orderly fashion, in the process avoiding the *ad hoc*, crisis-oriented scenario that characterized the chip mill experience in the state.

For this to happen would require a change in the institutional environment in Missouri within which the chip mill and other forestry-related issues are addressed. One innovative recommendation offered in the committee's final report suggested the establishment of a permanent statewide Forest Resource Council that would be responsive to forest and environmental issues, both present and potential, that affect the state. Such a council would be comprised of representatives of the entire spectrum of Missourians with an interest in the status and management of Missouri's forest land resources. As described in the committee's recommendation, the council would serve at least four key roles (GACCM: 174-175):

1) Promote collaboration and provide an ongoing public forum among landowners, loggers, wood-based industries, environmental interests, the tourism industry, public agencies and others with a vital vested interest in the well-being of Missouri's forest resource;
2) Advise the Governor and State, county, and local governments on sustainable forest resource policies and practices;
3) Coordinate priority forestry research efforts in the state and develop and implement initiatives in sustainable forest management; and

4) Be comprised of appointees submitted by the groups involved and confirmed by Senate, and assigned to the Department of Conservation for administrative support.

In addition to its functions in providing advice to policymakers and coordinating research efforts contributing to sustainable forests in Missouri, a critical role of such a council would be that of maintaining a viable *public forum* in which citizens with diverse interests in the state's forest resources could express those concerns with full confidence that they will be recognized and addressed. Such a council might be expected over time to grapple with some of the vexing issues that were short-circuited in the committee's deliberations by ideologically based fears. It is a sense of *trust* on the part of citizens that creates the possibility of a legitimate and genuinely democratic self-governance capable of making the idea of sustainable forest lands a reality in Missouri.

CONCLUSION

The Governor's Advisory Committee on Chip Mills performed a valuable service for Missouri citizens; and given the constraints under which it operated, the range of responses to the recommendations in its final report was by no means surprising, nor should it necessarily be viewed as an indication of the committee's failure to successfully complete its task. The committee brought about a renewed focus on forests and forest management in Missouri, and in the process, produced a much-needed baseline document that will serve as a reference for forestry in the state for some time. The process itself was characterized by an unprecedented level of public participation. Indeed, it could be said that this was the first statewide debate on natural resources in Missouri to experience the full impact of the arrival of the information age. Meeting minutes and draft reports disseminated on the Internet ensured that the public would remain aware of and intimately involved in each step of the process. From a long-term perspective, Missourians have not been accustomed to examining their forests, forest industry, and practices of forest landowners in such a holistic fashion; and it would be unrealistic to expect major changes to result from an initial effort to do so. What was essential, and what the committee's efforts did succeed in accomplishing, was to define the terrain for Missouri forests and forestry to a statewide audience to whom, particulars aside, such matters are important. The committee certainly did not resolve all of the issues involved in such a complex problem. But by bringing Missouri's forest lands and natural resources to the forefront of public consciousness, and conducting this public discussion not merely in terms of such general notions as "healthy Missouri forests," but with widespread awareness of the multifaceted nature of the ecological, economic, and social dimensions of forests and forestry in Missouri, the Governor's Advisory Committee helped set the stage for an ongoing and more enlightened and effective discussion of these questions in the future.

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APPENDIX A

The Montreal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests

Criterion 1: Conservation of biological diversity

Ecosystem diversity

1. Extent of area by forest type relative to total forest area
2. Extent of area by forest type and by age class or successional stage
3. Extent of area by forest type in protected area categories as defined by International Union for the Conservation of Nature or other classification systems
4. Extent of areas by forest type in protected areas defined by age class or successional stage
5. Fragmentation of forest types

Species diversity

6. The number of forest dependent species
7. The status (rare, threatened, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment

Genetic diversity

8. Number of forest dependent species that occupy a small portion of their former range
9. Population levels of representative species from diverse habitats monitored across their range

Criterion 2: Maintenance of productive capacity of forest ecosystems

10. Area of forest land and net area of forest land available for timber production
11. Total growing stock of both merchantable and nonmerchantable tree species on forest land available for timber production
12. The area and growing stock of plantations of native and exotic species
13. Annual removal of wood products compared to the volume determined to be sustainable
14. Annual removal of nontimber forest products (e.g., fur bearers, berries, mushrooms, game) compared to the level determined to be sustainable

Criterion 3: Maintenance of forest ecosystem health and vitality

15. Area and percent of forest affected by processes or agents beyond the range of historic variation (e.g., by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinization, and domestic animals)
16. Area and percent of forest land subjected to levels of specific air pollutants (e.g., sulfates, nitrate, ozone) or ultraviolet B that may cause negative impacts on the forest ecosystem
17. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g., soil, nutrient cycling, seed dispersion, pollination) and/or ecological continuity

Criterion 4: Conservation and maintenance of soil and water resources

18. Area and percent of forest land with significant soil erosion
19. Area and percent of forest land managed primarily for protective functions (e.g., watersheds, flood protection, avalanche protection, riparian zones)
20. Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation
21. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties

22. Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities
23. Percent of water bodies in forest areas (e.g., stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability
24. Percent of water bodies in forest areas (e.g., stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation, or temperature change
25. Area and percent of forest land experiencing an accumulation of persistent toxic substances

Criterion 5: Maintenance of forest contribution to global carbon cycles

26. Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages
27. Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon
28. Contribution of forest products to the global carbon budget

Criterion 6: Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies

Production and consumption

29. Value and volume of wood and wood products production, including value added through downstream processing
30. Value and quantities of production of nonwood forest products
31. Supply and consumption of wood and wood products, including consumption per capita
32. Value of wood and nonwood products production as a percentage of gross domestic product
33. Degree of recycling of forest products
34. Supply and consumption/use of nonwood products

Recreation and tourism

35. Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land
36. Number and type of facilities available for general recreation and tourism, in relation to population and forest area
37. Number of visitor days attributed to recreation and tourism, in relation to population and forest area

Investment in the forest sector

38. Value of investment, including in forest growing, forest health and management, planted forests, wood processing, recreation, and tourism.
39. Level of expenditure on research and development, and education
40. Extension and use of new and improved technology
41. Rates of return on investment

Cultural, social, and spiritual needs and values

42. Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social, and spiritual needs and values
43. Nonconsumptive-use forest values

Employment and community needs

44. Direct and indirect employment in the forest sector and the forest sector employment as a proportion of total employment
45. Average wage rates and injury rates in major employment categories within the forest sector
46. Viability and adaptability to changing economic conditions of forest dependent communities, including indigenous communities
47. Area and percent of forest land used for subsistence purposes

Criterion 7: Legal, institutional, and economic framework for forest conservation and sustainable management

Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it:

48. Clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process
49. Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors
50. Provides opportunities for public participation in public policy and decision making related to forests and public access to information
51. Encourages best practice codes for forest management
52. Provides for the management of forests to conserve special environmental, cultural, social, and/or scientific values

Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to:

53. Provide for public involvement activities and public education, awareness and extension programs, and make available forest-related information
54. Undertake and implement periodic forest-related planning, assessment, and policy review, including cross-sectoral planning and coordination
55. Develop and maintain human resource skills across relevant disciplines
56. Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management
57. Enforce laws, regulations, and guidelines

Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through:

58. Investment and taxation policies and a regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, nonmarket economic valuations, and public policy decisions in order to meet long-term demands for forest products and services
59. Nondiscriminatory trade policies for forest products

Capacity to measure and monitor changes in the conservation and sustainable management of forests, including:

60. Availability and extent of up-to-date data, statistics, and other information important to measuring or describing indicators associated with the seven criteria
61. Scope, frequency, and statistical reliability of forest inventories, assessment, monitoring, and other relevant information
62. Compatibility with other countries in measuring, monitoring, and reporting on indicators

Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services, including:

63. Development of scientific understanding of forest ecosystem characteristics and functions
64. Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest-related resource depletion or replenishment in national accounting systems
65. New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies
66. Enhancement of ability to predict impacts of human intervention on forests
67. Ability to predict impacts on forests of possible climate change

(USDA Forest Service 1997)

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Flader, Susan L., ed..
2004. **Toward sustainability for Missouri forests**. Gen. Tech. Rep. NC-239. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 251 p.

Reviews the nature and history of Missouri forests, private and public, and considers the status and prospects for ecological, watershed, and socioeconomic sustainability, and sustainable balance among timber growth, non-timber resources, harvest, and consumption. Discusses sustainable silviculture, including Pioneer Forest, and trends in demands, citizen attitudes, and policy development, with a case study on chip mills.

KEY WORDS: ecology, silviculture, Ozarks, history, policy, Pioneer Forest, chip mills.

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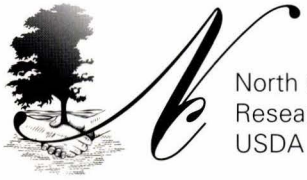

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